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UNITED STATES ARMY.

HISTORICAL PAPERS

RELATING TO THE CORPS OF ENGINEERS AND TO ENGINEER TROOPS OF THE UNITED STATES ARMY

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WASHINGTON BARRACKS, D. C.
PRESS OF THE ENGINEER SCHOOL,
1904.

NUMBER 16,
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Historical Papers

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and to Engineer Troops in
the United States Army

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HISTORICAL SKETCH
OF THE CORPS OF ENGINEERS

AND REMARKS UPON ITS ORGANIZATION AND DUTIES.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., October 20, 1876.

SIR: Referring to your indorsement of September 4, 1876, upon the proceedings of the commission for the reform and reorganization of the Army of the United States, in which you state you will be pleased to receive any opinions or suggestions of mine touching the subject before the commission, I have the honor to present the following remarks concerning the organization of the Corps of Engineers, introducing the same with historical sketches of the two corps, compiled by Lieut. Col. Thomas L. Casey, Corps of Engineers.

HISTORICAL SKETCH OF THE CORPS OF ENGINEERS.

Upon the breaking out of the war of the Revolution, the country was singularly deficient in persons acquainted with the duties of military engineers.

With the exception of a few who had seen service at Louisburg, Lake George, Ticonderoga, Crown Point and Quebec, and had thus gained some practical experience in the construction, attack, and defense of fortified places, there was scarcely any engineering skill or talents in the patriot service. Nevertheless it was important that such officers should be appointed for the Continental Army, and on the 16th of June, 1775, the Continental Congress—

> *Resolved*, That there be one chief engineer at the grand Army, and that his pay be sixty dollars per month.
>
> That two assistants be employed under him, and that the pay of each of them be twenty dollars per month.

> That there be one chief engineer for the Army in a separate department, and two assistants under him; that the pay of the chief engineer be sixty dollars per month, and the pay of his assistants each, twenty dollars per month.

The pay given above to the office of chief engineer, and assistant engineer, was the compensation which attached at that time to the grades of colonel and captain respectively, and the officers appointed in the Army under this resolution were commissioned with those ranks respectively, and this practice continued for the first year of the war, but by April, 1776, assistant engineers were commissioned with as high rank as lieutenant-colonel in the Continental establishment.

On the 27th December, 1776, Congress—

> *Resolved*, That General Washington shall be, and he is hereby, vested with full, ample, and complete powers to raise and collect together, in the most speedy and effectual manner, from any or all of these United States, sixteen battalions of infantry, in addition to those already voted by Congress; to appoint officers for the said battalions of infantry; to raise, officer, and equip three thousand light-horse, three regiments of artillery, and a corps of engineers, and to establish their pay. * * * That the foregoing powers be vested in General Washington for and during the term of six months from the date hereof, unless sooner determined by Congress.

Under this law it is probable that some organization styled a Corps of Engineers, was established in the Army under the rules and regulations of General Washington.

The news of the conflict of the colonies with Great Britain, together with the efforts of our diplomatic agents abroad, soon brought a crowd of foreign officers, principally French, to our shores, some of whom had been educated as military engineers, and were commissioned in our Army as such, and assigned to the various armies and commands as needed. Among the arrivals in the early part of 1777 were four officers from the royal corps of engineers of the French army, who were commissioned, respectively, in the engineers, with the rank, one, of brigadier-general, two, of colonel, and one of lieutenant-colonel, the brigadier-general, Louis le Bégue du Portail, taking precedence and rank of all other engineers in the service.

The propriety of establishing by law, a Corps of Engineers in the Army, was one of the subjects which attracted the attention of Congress, and, on the 6th March, 1778, a letter, dated the 3d of the same month, from a congressional committee in the camp, inclosing a plan for the establishment of a Corps of Engineers, was received in Congress, but action on the matter was then postponed. On the 27th May, 1778, the following resolution was passed:

> *Resolved*, That in the Engineering Department three companies be established, each to consist of—

	Pay per month.
1 captain	$50 00
3 lieutenants, each	33 33⅓
4 sergeants, each	10 00
4 corporals, each	9 00
60 privates, each	8 33⅓

> These companies to be instructed in the fabrication of field-works, as far as relates to the manual and mechanical part. Their business shall be to instruct the fatigue parties to do their duty with celerity and exactness, to repair injuries done to the works by the enemy's fire, and to prosecute works in the face of it.
>
> The commissioned officers to be skilled in the necessary branches of mathematics; the non-commissioned officers to write a good hand.

These were the first companies of engineer troops organized in our service; and although the law for the creation of a Corps of Engineers was still delayed, the fact that at this time the engineers in the service must have had some organization in the form of a corps is apparent from the resolution of April 18, 1778, as follows:

> *Resolved*, That General Washington be authorized and directed forthwith to convene a council, to consist of the major-generals in the State of Pennsylvania and the general officer commanding the Corps of Engineers, and with the advice of the said council to form such a plan for the general operations of the campaign as he shall deem consistent with the welfare of these States.

And also from the resolution of June 13, 1778, namely:

> *Resolved*, That Mons. du Cambray be annexed to the Corps of Engineers commanded by Brigadier du Portail, with the rank and pay of a lieutenant-colonel.

On the 11th March, 1779, the following resolutions constituting a Corps of Engineers were passed in Congress:

> *Resolved*, That the engineers in the service of the United States shall be formed in a corps and styled the "Corps of Engineers," and shall take rank and enjoy the same rights, honors, and privileges with the other troops in the Continental establishment

> That a commandant of the Corps of Engineers shall be appointed by Congress, to whom their orders or those of the Commander-in-Chief shall be addressed, and such commandant shall render to the Commander-in-Chief, and to the Board of War, an account of every matter relative to his department.
>
> That the engineers shall rank in their own corps according to the dates of their respective commissions.
>
> That every year, previous to the opening of the campaign, the commandant of the corps shall propose to the Commander-in-Chief, and to the Board of War, such a disposition of the engineers as he shall judge most advantageous, according to the knowledge which he is supposed to have of their talents and capacity.
>
> *Resolved*, That the Board of War be empowered and directed to form such regulations for the Corps of Engineers and companies of sappers and miners as they judge most conductive to the public service, and that the board report such allowances as they judge adequate and reasonable to be made to the officers of the Corps of Engineers for traveling charges, and when on command at a distance from camp, or in places where they cannot draw rations.

On the 11th of May, 1779, the following resolutions concerning the engineers were passed:

> *Resolved*, That the pay and subsistence of the engineers, and of the officers and men of the companies of sappers and miners shall be the same with those of officers of the like rank, and of the men, in the artillery of these States.
>
> That Brig. Gen. du Portail be appointed commandant of the Corps of Engineers and companies of sappers and miners.

Under the operations of these laws, the Corps of Engineers, with its companies of sappers and miners, served in the armies during the war of the Revolution, with efficiency and distinction, and numbers of its officers were brevetted by Congress for their distinguished services. The commandant of the corps was especially rewarded, as appears from the resolution of November 16, 1781, as follows:

> *Resolved*, That Brig. Gen. du Portail, commanding officer of the Corps of Engineers, in consideration of his meritorious services, and particularly of his distinguished conduct in the siege of York, in the State of Virginia, be, and he is hereby, promoted to the rank of major-general.

It is difficult to enumerate the officers composing the Corps of Engineers in the Army of the Revolution, but it is believed that it did not contain, outside of the companies of sappers and miners, any officer of a lower grade than captain. The names of one brigadier-general and commandant of the corps, of six colonels, of eight lieutenant-colonels, of three majors, and of ten captains, have been recovered. There is no question but that the corps was larger than the numbers given above.

In November of 1783, this Corps of Engineers and its companies of sappers and miners, were disbanded, and mustered out of service, having agreed to accept the commutation of five years' pay in lieu of the half-pay for life; and while many of the foreign officers returned to their homes in Europe, a number remained in the United States and became citizens of the country.

During the period which elapsed between the close of the revolutionary war, and the inauguration of the Government in 1789 under the present Constitution, nothing occurred which required the employment of military engineers.

As early, however, as 1789, in the plan submitted by the Secretary of War, General Henry Knox, to the President, for the general arrangement of the military forces of the country, there was recommended, as a part of the military establishment of the United States, "a small corps of well-disciplined and well-informed artillerists and engineers."

Under the pressure of the relations existing between this country and the principal European countries, and the message of President Washington of December 3, 1793, Congress, on the 20th March, 1794, authorized the President to fortify certain harbors along the coast, and the next day appropriated funds for the same. There were no engineers in the Army to carry on these works, and so the President directed the temporary appointment of a number of engineers, to design and superintend the construction of the works, dividing the coast up into districts, and appointing one or more engineers for each district.

The gentlemen appointed to these positions were foreign-born, and a number of them had been in the Corps of Engineers of the revolutionary army. Among those appointed may be mentioned—

Stephen Rochefontaine,
Charles Vincent,
Peter Charles L'Enfant,
John Jacob Ulrich Rivardi,
John Vermonet,
Nicholas Francis Martinon,
Paul Hyacinte Perrault,

who were appointed for, and entered upon, the discharge of this duty, between the 25th of March and 12th of May of the year 1794.

On the 9th May, 1794, Congress passed an act providing for raising and organizing, for a term of three years, a corps of artillerists and engineers, to be incorporated with the corps of artillery in service, the entire number to consist of 992 rank and file.

The organization to be as follows:

1 lieutenant-colonel, commandant.
1 adjutant.
1 surgeon.
    4 battalions.
4 majors.
4 adjutants and paymasters.
4 surgeon's mates.
    16 companies, each to consist of—
1 captain.
2 lieutenants.
2 cadets; 4 sergeants; 4 corporals; 42 privates, sappers and miners; 10 artificers; and 2 musicians.

The Secretary of War was to provide the necessary books, instruments, and apparatus for the use and benefit of the corps, and the President was authorized to employ such proportions of said corps, in the field, on the frontiers, or in the fortification of the sea-coasts as he might deem consistent with the public service.

The filling up, and organization of the corps was at once commenced. It was stationed at West Point, and at the same time a military school at that place was organized; but the apparatus and books were burned in 1796, and the school suspended until 1801, when it was revived and placed under the direction of Major Jonathan Williams, of the 2d Regiment of the Corps of Artillerists and Engineers. The organization of the corps was completed by the spring of 1795, Stephen Rochefontaine being appointed the lieutenant-colonel and commandant, and Henry Burbeck, Louis Tousard, J. J. U. Rivardi, and Constant Freeman the majors. It will be seen from this list, that several of the temporary engineers engaged upon the fortification of the coast, were commissioned in the Corps of Artillerists and Engineers, and as long as this corps existed, there were always a number of its officers engaged exclusively upon the construction and repair of the sea-coast works. Some of the companies were in garrison in the fortifications, but the main body was at West Point.

By the act of March 3, 1795, the Corps of Artillerists and Engineers was continued indefinitely, and its completion authorized.

By the act of May 30, 1796, to ascertain and fix the military establishment of the United States, the Corps of Artillerists and Engineers was to form part of the same, and it was to be completed in conformity to the organic act of 1794.

Laincourt, who visited West Point in 1796, states, that he found at that place four battalions of artillerists and engineers, composed of about two hundred and fifty men each, mostly made up of foreigners. But ten officers were present, representing "all nations."

The threatened disturbances with France continuing, a second regiment of artillerists and engineers was authorized by the act of April 27, 1798. By its terms, the regiment was to consist of—

1 lieutenant-colonel, commandant.
1 adjutant.
1 surgeon.
3 battalions.
3 majors.
3 adjutants and paymasters.
3 surgeon's mates.
12 companies, each to consist of—
1 captain.
2 lieutenants.
2 cadets; 4 sergeants; 4 corporals; 42 privates, sappers and miners; 10 artificers; and 2 musicians.

It was placed upon the same footing precisely as the first regiment raised, and was to be supplied with the same books and apparatus, and to do duty in the same places, and times, as were prescribed for the former.

The officers were appointed to rank from June 1, 1798, and John Doughty, was appointed the lieutenant-colonel and commandant of the regiment; Benjamin Brooks, Adam Hoops, and Daniel Jackson, being majors.

By the act of July 16, 1798, to augment the Army of the United States, the President was authorized to appoint a number not exceeding four teachers of the arts and sciences, necessary for the instruction of the artillerists and engineers.

There was also authorized by this act an inspector of artillery, to be taken from the line of artillerists and engineers.

The recommendations leading to the above legislation will be found in an extract of a letter from the Secretary of War (James McHenry) to the Hon. Samuel Sewell, chairman of the committee of defense, &c., dated War Department, June 28, 1798, as follows:

> 3d. The act providing for raising and organizing a corps of artillerists and engineers, and the act to provide an additional regiment of the same, both enjoin the procurement at the public expense of all necessary books, instruments, and apparatus, for the benefit of the said respective regiments.
>
> The Secretary, without designing to derogate from the merits of the officers appointed to the corps established by the acts cited, feels it his duty to suggest, that other and supplementary means of instruction to the books and instruments to be provided, appear to be absolutely indispensable to enable them to acquire a due degree of knowledge in the objects of their corps. It is certain that the best faculties and inclinations for the arts and sciences cannot be unfolded, and applied to useful purposes, when proper encouragement and assistance have been denied or neglected.
>
> The art of fortification is connected with so many others, is of such extent, and its operations dependent on, and affected by circumstances so infinitely varied, that it is impossible any man can be rendered master of it by experience alone. Besides, the knowledge acquired by experience is often the results of our own faults, and acquired by a heavy, and it may be, in this art, disastrous expense to the public.
>
> It is certainly to be wished that more attention had been paid to this subject, and that past recommendations had found a favorable access to the ear of Congress.
>
> If the present moment does not admit of carrying into effect all that is desirable, and ought, under different circumstances, to be done, to create a body of qualified and scientific engineers, it may, notwithstanding, be advisable to advance towards this point by such measures as are compatible with our present situation.
>
> * * * * * * *
>
> It is therefore submitted whether provision ought not to be made for the employment of three or four teachers of the enumerated sciences, to be attached generally to the two corps of artillerists and engineers, and obligated to give instruction and lessons at such times, places, and under such regulations as the President may direct.
>
> The employment of teachers would give the intended effect to the provision of the laws for the appointment of two cadets to each company. It was supposed that these cadets would form a nursery, from which qualified officers might be drawn to fill vacancies, but it must occur, that without proper masters to teach them the sciences necessary to the engineers and artillerists, this nursery can produce no valuable plants.

In a paper upon the proper changes that should be made in the military establishment, written by the Secretary of War, James McHenry, and dated December 24, 1798, after recommending that the organization of the Second Regiment of Artillerists and Engineers should be made the same as that of the First, he says:

> It is deeply to be lamented that a very precious period of leisure was not improved toward forming among ourselves engineers and artilllerists, and that, owing to this neglect, we are in danger of being overtaken by war without a competent number of characters of these descriptions. To form them suddenly is impracticable; much previous study and experiment are essential. If possible to avoid it, a war ought not to find us unprovided. * * * *
>
> In the meanwhile, it is conceived to be advisable to endeavor to introduce from abroad at least one distinguished engineer, and one distinguished officer of artillery. They may be sought for preferably in the Austrian, and next in the Prussian armies. The grade of colonel, with adequate pecuniary compensations, may attract officers of a rank inferior to that grade in those armies, who will be of distinguished abilities and merit. But in this, as we know from past experience, nothing is more easy than to be imposed upon, nothing more difficult than to avoid imposition, and that, therefore, should the measure be sanctioned by a law, it will be requisite to commit the business of procuring such characters to some very judicious hand, under every precaution that can put him on his guard.
>
> It is also suggested that an inspector of fortifications is much wanted. In case of a legislative provision on this subject, the officer may either be drawn from the Corps of Artillerists and Engineers, or it may be left discretionary with the President to choose him where he pleases.

By the act of March 2, 1799, to augment the Army, an additional battalion of artillerists and engineers was authorized, which completed the Second Regiment of Artillerists and Engineers to the same strength as the First Regiment.

And by the act of March 3, 1799, for the better organization of the troops of the United States, the President was authorized to engage and appoint, distinct from the officers of the Corps of Artillerists and Engineers, two engineers with the rank of lieutenant-colonel, and to stipulate, and allow them respectively, such compensation as he shall find necessary and expedient.

The act also provided for the appointment of an inspector of fortifications, whose duties were to be assigned him by the Secretary of War, under the direction of the President, to be taken from the

Corps of Artillerists and Engineers, or other corps, and if he shall not be an officer in the artillery or Army, to be entitled to the rank of major in the Army.

It is not known whether the two officers of engineers, distinct from the Corps of Artillerists and Engineers, with the grade of lieutenant-colonel, were ever appointed; it is probable they were not. Nevertheless, in the act of May 14, 1800, to discharge the officers and men raised under the acts of March 2 and 3, 1799, it was provided that "the engineers, the inspector of artillery, the inspector of fortifications, and the two regiments of artillerists and engineers should be retained in service."

No further legislation affecting the Corps of Artillerists and Engineers is found until the act of March 16, 1802, fixing, and reducing materially, the military establishment. By this act the Corps of Artillerists and Engineers was discontinued, and from it two corps—a regiment of artillerists, and a corps of engineers—were created. The following remarks of Secretary McHenry, precedent to the above legislation, will be found of interest in this connection. They are extracted from a report made by him to the President, on the 5th of January, 1800, upon the subject of the Military Academy, and re-organization of the Army:

> It is conceived that the entire union of the officers of artillerists and engineers in one corps, as in our present establishment, is not advisable. The art of fortification and the service of artillery, though touching each other in many points, are in the main distinct branches, and each so comprehensive that their separation is essential to perfection in either. This has been ascertained by long experience. Among the powers of Europe there is not one recollected, which at the present day, is not conscious of this truth. When any of them have attempted to unite these corps, the disadvantages which resulted were soon felt to be so momentous, as to produce conviction that each required a separate organization. Such an union was once attempted in France. According to an ordinance of the 8th of December, 1755, the artillery and engineer corps of that nation, which had been separate, were combined in one. The experiment, however, was of short duration. In 1758, the engineer corps was disjoined from the corps of artillery, and called as before, the corps of engineers, since which time these corps have remained separate.

The recommendations of Secretary McHenry with reference to the revival of the Corps of Engineers, contained in the same report, are as follows:

> The regiment of engineers consisting entirely of officers, if we exclude the companies of miners, it remains to speak of its organization. Let it consist of, viz, two lieutenant-colonels, one first and one second, as already provided by law, three majors, twelve captains, twenty-four first lieutenants, twentv-four second lieutenants, twenty-four cadets.
>
> The companies of miners, and their labors, to be under the direction and immediate command of officers of this corps, and to make a part thereof.
>
> It will be perceived, and it is observed with regret, that the engineer regiment cannot be immediately formed by the mere act of transferring into it officers from any of the existing regiments. In order to answer its high destination it must be filled slowly, and under the exercise of great caution and responsibility.

In a further communication of Secretary McHenry concerning the Military Academy, and the proposed revival of the Corps of Engineers, dated January 31, 1800, he says:

> A slight attention to circumstances and the actual position of our country, must lead to the conviction, that a well-connected series of fortifications is an object of the highest importance to the United States, not only as these will be conducive to the general security, but as a means of lessening the necessity, and, consequently, the expense, of a large military establishment.
>
> * * * * * * *
>
> We must not conclude from these brief observations, that the service of the engineer is limited to constructing, connecting, consolidating, and keeping in repair fortifications. This is but a single branch of their profession, though, indeed, a most important one. Their utility extends to almost every department of war, and every description of general officers, besides embracing whatever respects public buildings, roads, bridges, canals, and all such works of a civil nature. I consider it, therefore, of vast consequence to the United States, that it should form in its own bosom, and out of its own native materials, men qualified to place the country in a proper posture of defense, to infuse science into our Army, and give to our fortifications that degree of force, connection, and perfection, which can alone counterbalance the superiority of attack over defense.

By the act of March 16, 1802, fixing the military peace establishment of the United States, it was enacted:

> SEC. 26. That the President of the United States is hereby authorized and empowered, when he shall deem it expedient, to organize and establish a Corps of Engineers, to consist of one engineer, with the pay, rank, and emoluments of a major; two assistant engineers, with the pay, rank, and emoluments of

> captains; two other assistant engineers, with the pay, rank, and emoluments of first lieutenants; two other assistant engineers, with the pay, rank, and emoluments of second lieutenant; and ten cadets, with the pay of sixteen dollars per month, and two rations per day; and the President of the United States is in like manner authorized, when he shall deem it proper, to make such promotions in the said corps, with a view to particular merit and without regard to rank, so as not to exceed one colonel, one lieutenant-colonel, two majors, four captains, four first lieutenants, four second lieutenants, and so that the number of the whole corps shall at no time exceed twenty officers and cadets.
>
> SEC. 27. That the said corps, when so organized, shall be stationed at West Point, in the State of New York, and shall constitute a Military Academy; and the engineers, assistant engineers, and cadets of said corps shall be subject at all times to do duty in such places and on such service as the President of the United States shall direct.
>
> SEC. 28. That the principal engineer, and, in his absence, the next in rank, shall have the superintendence of the said Military Academy, under the direction of the President of the United States; and the Secretary of War is hereby authorized, at the public expense, under such regulations as shall be directed by the President of the United States, to procure the necessary books, implements, and apparatus for the use and benefit of the said institution.

Under the operations of this act the following officers were appointed:

Major Jonathan Williams, of the late Second Regiment of Artillerists and Engineers, and Inspector of Fortifications, appointed major, Corps of Engineers, and principal engineer, and became the Superintendent of the Military Academy April 13, 1802.

William Amherst Barron, captain, Corps of Engineers, teacher of mathematics, April 13, 1802.

Jared Mansfield, captain Corps of Engineers, teacher natural and experimental philosophy, May 3, 1802.

Peter Anthony Dransey, first lieutenant, Corps of Engineers, (declined.)

James Wilson, first lieutenant Corps of Engineers.

Cadet Joseph Gardner Swift, student.

Cadet Simon M. Levy, student.

Cadet Walker Keith Armistead, student.

This was the beginning of the present Corps of Engineers, and of the Military Academy at West Point. To quote the words of Major Williams—

> A part only of the officers were appointed soon after the passage of the act, of whom the major, who was *ex officio* the chief engineer, and two captains, took charge of the academy, the students of which were the cadets belonging to the regiment of artillery. The major occasionally read lectures on fortifications, gave practical lessons in the field, and taught the use of instruments generally. The two captains taught mathematics; the one in the line of geometrical, the other in that of algebraical demonstration.

From its very organization, some commissioned officers of the corps were engaged upon the fortifications of the coast, and the majority of those who acted the part of teachers, during the first two or three years of the existence of the academy, were soon replaced by teachers and professors appointed to instruct in special subjects. By February of 1808, but one officer of the corps remained at the Military Academy, who served in the capacity of Acting Superintendent, and also instructor of certain branches. In the words of Colonel Williams—

> It was not probably foreseen, that although the headquarters of the corps might be at West Point, yet the duties of the individual officers necessarily spread them along our coast from one extremity of the United States to the other, and, as the whole number of officers can be no more than sixteen, they could not in their dispersed state constitute a military academy. The incongruity of a stationary and errant existence in the same corps, has been amply exemplified by experience.

It is not proposed to attempt any history of the Military Academy, or to quote the laws which affected it; it is sufficient to say that the charge and superintendency of that institution remained in the Corps of Engineers until July 13, 1866, when the superintendency passed to the Army at large, and that during the supervision of the Military Academy by the Corps of Engineers, it attained to its present state of efficiency and value to the country.

By the act of February 28, 1803, it was provided:

> SEC. 3. That the commanding officer of the Corps of Engineers be authorized to enlist, for a term not less than three years, one artificer and eighteen men, to aid in making practical experiments, and for other purposes, &c., &c.

By the act of April 10, 1806, for establishing rules and articles for the government of the armies of the United States, it was enacted:

> ART. 63. The functions of the engineers being generally confined to the most elevated branch of military science, they are

> not to assume, nor are they subject to be ordered on any duty beyond the line of their immediate profession, except by the special order of the President of the United States, but they are to receive every mark of respect to which their rank in the Army may entitle them respectively, and are liable to be transferred at the discretion of the President from one corps to another, regard being paid to rank.

As this law has an important bearing upon the administration and duties of the Corps of Engineers, it is proper that the facts leading to its enactment should be stated.

In the latter part of 1802, in which year the Corps of Engineers was revived and stationed at West Point, a dispute arose between Lieutenant-Colonel Williams, commandant of the corps, and Captain George Izard, of the regiment of Artillerists, who with his company was stationed at the same post, concerning the right of Colonel Williams to exercise command over these troops of the artillery line. The matter was referred to General Dearborn, who was at the head of the War Department during the administration of Mr. Jefferson, and who decided—

> That no officer, cadet, or soldier of the Corps of Engineers shall be subject to the orders of any officer of any other corps, but subject to the orders of the President only, or, when in actual service, to the orders of the commanding general; and no officer of engineers shall, under any circumstances, command any officer or any troops of any other corps, except by special orders of the President.

The articles of war in force at this time, were those published by order of Congress, September 20, 1776, and by the 25th and 26th articles, officers of engineers felt themselves entitled to command according to their rank, when they were thrown on duty with other corps of the Army. General Dearborn was of opinion, that the Corps of Engineers as then organized, being composed mainly of officers, and being engaged in scientific pursuits, should not exercise command in the line, unless by special assignment of the President. The decision of General Dearborn was received with great mortification and dissatisfaction by the officers of the Corps of Engineers, the greater part of whom had been transferred from the line to form the corps. They could not perceive by what authority or rule the Secretary of War could deprive them of their lawful prerogatives. On the 30th of November, 1804, they addressed a memorial to the President of the United States, appealing to his sense of justice from the decision of the Secretary of War, which decision they conceived materially affected their standing in the Army, and abridged their just rights, but no answer was made to their memorial.

In this state of things the Corps of Engineers felt their situation to be very embarrassing and unpleasant, and the whole corps at length determined to resign their commissions. The two field officers of the corps, Lieutenant-Colonel Williams and Major Wadsworth, did actually resign. Under these circumstances a letter, dated March 29, 1805, was written to Colonel Williams by General Wilkinson, the Commmander-in-Chief, with the approbation of the War Department, as follows:

> I am authorized by the Secretary of War to inform you, that if agreeable to you, the President will re-appoint you to the command of the Corps of Engineers, on the express condition, that you are not to interfere with the discipline, police, or command of the troops of the line but by his orders, to which alone you are to be subject, and that in all other respects, you are to enjoy the honors due to your rank. Should this proposition be acceptable to you, you will be pleased to signify your disposition to the Secretary of War without delay, and in such explicit terms as may preclude misapprehension. The President is now at Monticello, but will be here about the 8th of the next month, at which time, should it be agreeable to you, you may make a visit to the city in order to pay your respects to our superior.
>
> Permit me, sir, to add my earnest hopes that you may not pause for a determination in this case, because, I am convinced, you will stand acquitted by every professional man of intelligence and honor, should you embrace the proposition. It is unquestionable that the elevated pursuits of the Corps du Génie do not allow time for the necessary attentions to the details, police, and discipline of the line, and it follows, as in other services, that the officers of that corps should not be burdened with the responsibility attached to duties in their nature incompatible. But admitting the practice of other nations, &c., to be at variance with our own, if the United States are acknowledged to be sovereign and independent, we cannot deny to the regular authority, powers and capacities to ordain such subordinate arrangements, as may be deemed conducive to the public weal, and it is the duty of every good citizen to conform, when such conformity does not affect his honor. In the case before us the suspension of ex-official command, is deemed essential to the interests of a particular corps, but no subversion of inherent principles or fundamental right takes effect, because you are held liable to general command upon the orders of the President.

> I beg to hear from you soon, and, I hope to my satisfaction. You owe much to the partiality of the President, more to the claims of your country.

This correspondence led to the issuing of the following General Order, dated April 17, 1805:

> As the scientific pursuits of the Corps of Engineers do not allow time for attention to details, police, and discipline of the troops of the line, it follows, as in other services, that the officers of that corps should not be burdened with the responsibility attached to duties in their nature incompatible.
>
> The President has thought proper to decide, that the officers of the engineers shall not interfere with the discipline, police, or command of the troops of the line *unless by his special order, to which alone they are subject.*
>
> But this suspension of official command, though deemed essential to the interests of a particular corps, does not subvert any inherent principle or fundamental right, because the superior officers of engineers are held liable to be called into general command, whenever the public service may require, and the will of the President directs.
>
> In all cases not affected by this regulation, the officers of the Corps of Engineers are invariably to enjoy the respect due to their commissions, and they are to receive the same honors which are paid to the officers of similar grade in the line of the Army.

On the 19th of April, 1805, Colonel Williams accepted the reappointment of chief engineer and lieutenant-colonel, Corps of Engineers, and on the 10th of the following April (1806) the 63d article of war was enacted to give to the General Order of April 17, 1805, the force of law.

Under the operations of this law, upon the breaking out of war with Great Britain, Colonel Williams applied for command in the line of the Army, which was authorized by the President, under date of June 23, 1812, in the following instructions to General Bloomfield, whose headquarters were in New York City:

> It is the pleasure of the President, that whenever the exigencies of the service may require the talents and knowledge of the officers of the Corps of Engineers, beyond the line of their immediate profession, you may assign to those under your command such duties in the line of the Army, as may comport with their rank.

and in the early days of July, Colonel Williams was ordered to take the command of Castle Williams on Governor's Island.

Again, on the 6th of April, 1813, Col. J. G. Swift, Chief Engineer, reported himself for duty to Gen. George Izard, the commandant of the department including New York Harbor, and by a special order of the President received the command of Staten Island, with a brigade, composed of Col. Samuel Hawkins's and Col. Alexander Deniston's regiments of infantry, the 32d and 41st, which command he exercised in addition to his duties as Chief Engineer, and his charge of the Military Academy. Colonel Swift was at that time personally superintending the fortifications of New York Harbor.

On the 23d of February, 1808, the corps was filled up by regular promotions to the full numbers authorized by the organic act of March 6, 1802, Jonathan Williams being the Chief Enigneer and colonel, Jared Mansfield the lieutenant-colonel, and Alexander Macomb and Joseph G. Swift the majors; and, with the exceptions of Lieutenant-colonel Mansfield, who had been surveyor-general of the Northwest Territory since November 1, 1803, with office at Cincinnati, and Lieut. Alden Partridge, who was retained at the Military Academy, all the officers of the corps were spread along the coasts in charge of active operations upon the fortifications. The office of the Chief of Engineers was in New York Harbor.

By the act of April 29, 1812, making further provisions for the Corps of Engineers, it was enacted:

> SEC. 1. That there be added to the Corps of Engineers two captains; two first lieutenants; two second lieutenants; with the usual pay and emoluments according to their grades respectively; and one paymaster, to be taken from the subalterns of engineers, with the pay and emoluments of a regimental paymaster, and that there be attached to the said corps, either from the troops now in service or by new enlistments, as the President of the United States may direct, four sergeants, four corporals, one teacher of music, four musicians, nineteen artificers, and sixty-two men, which non-commmissioned officers, musicians, artificers, and men, together with the artificers and men already belonging to the Corps of Engineers, shall be formed into a company, to be styled a company of bombadiers, sappers, and miners, and be officered from the Corps of Engineers, according as the commanding officer of that corps may, with the approbation of the President of the United States, direct.
>
> SEC. 6. That so much of the twenty-sixth section of the act entitled "An act fixing the military peace establishment," passed the 16th day of March, 1802, as confines the selection of the command of the Corps of Engineers to the said corps be, and the same is hereby, repealed.

On the 6th of July, 1812, Lieutenant-Colonel Alexander Macomb, of the corps, was appointed colonel of the Third Regiment of Artillery, and on the 31st of July of the same year, Col. Jonathan Williams, Chief Engineer, resigned his commission in the Army in consequence of the dissatisfaction expressed by some of the artillery at his being assigned to the command of Castle Williams, New York Harbor, and the complications arising out of the same, which threatened to deprive him of this command, to which he felt himself entitled by his rank and services.

Under the operations of the act of April 29, 1812, and the casualties referred to above, Joseph G. Swift became colonel and Chief Engineer, Walker K. Armistead lieutenant-colonel, and George Bomford and William McRee majors; and the corps consisted of one colonel, one lieutenant-colonel, two majors, six captains, six first lieutenants, six second lieutenants, and a company of bombadiers, sappers, and miners, of one hundred and thirteen enlisted men.

War against Great Britian was declared June 15, 1812, and as many of the officers of engineers as could be furnished, were assigned to the staffs of the various generals commanding the military districts, with whom they served with credit during the war. The company of bombadiers, sappers, and miners, from the 9th of June, 1814, served along the Niagara frontier, and especially at Fort Erie, under Capt. and Bvt. Maj. Eleazer D. Wood, and in the sortie from Fort Erie.

By War Department regulations of February 28, 1815, signed by James Monroe, the commandant of the United States Corps of Engineers was announced as inspector of the Military Academy, and the appointment of a permanent superintendent for that institution was authorized. It was at this time, also, that the headquarters of the Engineer Department was established at New York.

By the act of March 3, 1815, fixing the military peace establishment, it was enacted—

> That the military peace establishment of the United States shall consist of such proportions of artillery, infantry, and riflemen, not exceeding in the whole ten thousand men, as the President of the United States shall judge proper, and that the Corps of Engineers as at present established be retained.

Under the operations of this law, which was held to continue the Military Academy also, the Corps of Engineers resumed its duties upon the works of fortification along the coast, the value of which had been demonstrated during the late war, and the absence of which had been severely felt at many points of the seaboard.

By the act of April 24, 1816, for organizing the general staff, &c., it is provided:

> SEC. 11. That the Ordnance Department be continued as at present organized, under the act of February 8, 1815, and that ordnance officers be assigned to their duties with the staff of the Army, in the same manner as from the Corps of Engineers.

On the 29th of April, 1816, a joint resolution of the two Houses of Congress was passed, as follows:

> That the President of the United States be, and he is hereby, authorized to employ, in addition to the Corps of Engineers as now established, a skillful assistant, whose compensation shall be such as the President of the United States shall think proper, not exceeding the allowance to the chief officer of that corps.

In accordance with this resolution, Gen. Simon Bernard, of the French Army, was attached to the Corps of Engineers, as an assistant engineer, with the pay and emoluments of a brigadier-general, the compensation which, under the existing laws, the Chief Engineer, Bvt. Brig. Gen. Swift, was then receiving.

On the 16th of November, 1816, the following regulation of the War Department, constituting a "Board of Engineers for Fortifications," was issued:

> A board shall be formed consisting of three officers of the Corps of Engineers, to be designated by the Secretary of War, and the officer of the Corps of Engineers assigned to the superintendence of the fortifications in any particular district, shall be attached to the board as a member, when it is acting in that district.
>
> It shall be the duty of the officers of this board to examine, in conjunction, all those positions where important permanent works are or may be proposed to be erected. They shall select the proper sites for, and form the plans of all new works. Where fortifications have been commenced or are finished, they shall report how far the sites for such fortifications have been judiciously selected, or whether or not the works are adequate to the defense of the respective positions, and they shall propose such alterations or additions to them as may be deemed necessary. At those places where naval can come in aid of land defenses, the board shall call upon the naval officer who shall have been assigned by the Secretary of the Navy to co-operate with the board at that station, and who, during that co-operation, shall be a member of the board.
>
> The report and plans adopted by the board, shall be submitted,

with accurate estimates by the officers of the Corps of Engineers, to the chief of that corps.

The navy officer will report directly to the Secretary of the Navy.

Any officer of the board who may disapprove of the reports and plans agreed upon by the board, may, if it be deemed necessary, submit to his chief separate and distinct reports, accompanied by the necessary plans and estimates.

The original reports and plans agreed upon by the board, as well as those reported by any member of it, shall be submitted by the Chief of the Corps of Engineers, with such remarks as he may deem proper, to the Secretary of War, for final adoption, and they shall be deposited in the secret bureau of the Department of War.

The Chief of the Corps of Engineers may assign the officers of that corps attached to the board, to superintend the construction of particular fortifications, when such assignment will not interfere with their duties as members of the board.

The board shall be immediately organized, and shall consist of the following named officers: Brigadier-General Simon Bernard, Colonel William McRee, and Lieutenant-Colonel J. G. Totten, and ——— ———, of the Navy.

The Chief Engineer will at all times furnish the board with such plans, reports, &c., as may be in his possession in relation to existing or contemplated works, and he shall designate the point at which the board shall commence its operations.

The Secretary of the Navy will be advised through the War Department of the time when, and the place where, the board shall meet for the performance of any of the duties assigned to it by these regulations.

GEO. GRAHAM,
Acting Secretary of War.

The board of engineers constituted by this order has been continued until the present time, and the methods therein prescribed for the location, planning, and executing of works of fortification for our seaboards, have uniformly been such as are prescribed in these regulations.

Its existence and organization have been made known to, and authorized by Congress, as will appear from repeated executive communications, and resolutions in Congress, especially the joint resolution of April 20, 1818, the resolution of the Senate of February 13, 1817, and of the House of Representatives of December 11, 1817, and February 9, 1821. A long series of reports of this board, from 1818 down to the present time, which have been laid before Congress, has been the groundwork and basis of the system of permanent fortifications which have been projected, and are still in progress of construction, along our maritime frontiers.

On the 3d of April, 1818, the headquarters of the Engineer Department were transferred from New York to Washington under the following order:

> DEPARTMENT OF WAR,
> *April 3, 1818.*
>
> SIR: The President having directed that the Headquarters of the Engineer Department be fixed at the seat of Government, you will make your arrangements accordingly. As soon as practicable, you will order the distribution of the officers of the gineer Corps, in such manner as the service of surveying sites, and the superintendence of the construction of works of defence may require.
>
> Until you can be otherwise accommodated, you will procure suitable rooms for offices.
>
> J. C. CALHOUN.
>
> Gen. J. G. SWIFT.

On the 7th of April, 1818, regulations for the government of the Engineer Department were issued by the Secretary of War, Mr. Calhoun, with the approval of the President. About this time the Engineer Department included the Corps of Engineers, the Topographical Engineers, and the Military Academy. The Topographical Engineers were "arranged to the Engineer Department, and made subject to the orders of the Chief Engineer and commanding engineers," by formal orders dated July 2, 1818, but a number of the Topographical Engineers had for nearly two years been doing duty under the Chief Engineer, with the board of engineers, and on other stations.

On the 12th of November, 1818, Bvt. Brig. Gen. J. G. Swift, Chief Engineer, resigned his commission in the Army, and on the 22d of the same month Lieut. Col. W. K. Armistead, Corps of Engineers, assumed the command of the corps. On the 10th of March, 1819, Lieutenant-Colonel Armistead was appointed Colonel, Corps of Engineers, and Chief Engineer, to rank from November 12, 1818.

By the act of March 2, 1821, to reduce and fix the military peace establishment, it was enacted:

> SEC. 1. That from and after the first day of June next, the military peace establishment of the United States shall be composed of four regiments of artillery, and seven regiments of infantry, with such officers of engineers, of ordnance, and of the staff, as are hereinafter provided for.

* * * * * * *

> SEC. 3. That the Corps of Engineers (bombardiers excepted) and the Topographical Engineers and their assistants, shall be retained in service as at present organized.

Under the operations of this act, Colonel Armistead resigned his office of Chief Engineer, and accepted the appointment of colonel of the Third Regiment of Artillery, while Brigadier and Brevet Major-General Alexander Macomb returned to service with the Corps of Engineers, as its Colonel and Chief Engineer. The enlisted men of the company of bombardiers, sappers, and miners, were either discharged, or transferred to the company of artillery which was stationed at West Point in its stead.

By the act of April 30, 1824, to procure the necessary surveys, plans, and estimates upon the subject of roads and canals, it was enacted:

> That the President of the United States is hereby authorized to cause the necessary surveys, plans, and estimates to be made of the routes of such roads and canals as he may deem of national importance in a commercial or military point of view, or necessary for the transportation of the public mail, designating, in the case of each canal, what parts may be made capable of sloop navigation; the surveys, plans, and estimates for each, when completed, to be laid before Congress.
>
> SEC. 2. That, to carry into effect the objects of this act, the President be, and he is hereby, authorized to employ two or more skillful civil engineers, and such officers of the Corps of Engineers, or who may be detailed to do duty with that corps, as he may think proper, and the sum of thirty thousand dollars be, and the same is hereby, appropriated, to be paid out of any moneys in the Treasury not otherwise appropriated.

Under this act the "Board of Engineers for Internal Improvements" was organized. It consisted of Bvt. Brig. Gen. Simon Bernard, assistant engineer; Lieut. Col. Joseph G. Totten, Corps of Engineers; Mr. John L. Sullivan, civil engineer; and had attached to it, for duty in the field, Major Abert, of the Topographical Engineers, and five assistant lieutenants; Capt. McNeil, of the Topographical Engineers, and five assistant lieutenants; and Mr. Shriver, civil engineer, and five civil engineer surveyors. Capt. Poussin, of the Topographical Engineers and Lieutenants Courtney and Dutton of the Corps of Engineers were on immediate duty with the board.

This board with changes from time to time in its membership continued until about 1832, when it seems to have been discontinued, but its functions since that date have been performed by special boards on river and harbor improvements, organized for temporary service upon particular works. During the continuance of the board of internal improvements a very great number of reconnaissances, surveys, plans, and estimates were made by the board, or under its directions, looking to the construction of works in the interest of commerce and navigation, and in its reports, the basis was laid for the system of river and harbor improvements, which have since added so much to the wealth of the nation.

On the 24th of May, 1828, Col. Alexander Macomb, Chief Engineer, was appointed major-general in the Army, and was directed to take the command of the same.

In relinquishing the command of the Corps of Engineers, General Macomb published the following orders, dated Washington, May 28, 1828:

> Major-General Macomb, in leaving the office of Chief Engineer, which he has filled for the last seven years, to take command of the Army, feels it but an act of justice to the officers attached to the Engineer Department to express the great satisfaction he has experienced from their zealous and efficient co-operation in every branch of the service connected with his duties.
>
> To the officers of the Corps of Engineers he makes his fullest acknowledgements for the judicious and faithful manner in which they have directed the construction of the fortifications, and other works confided to their superintendence, and for the unceasing efforts to sustain, in whatever situation they have been placed, the honor and reputation of the corps.
>
> To the officers of the Topographical Engineers, and those detailed from the line of the Army to assist in the surveys and reconnaissances relating to internal improvements, and to the gentlemen who have acted as civil engineers, Major-General Macomb in like manner tenders his acknowledgments.
>
> To the commissioners and superintendents of laying out and constructing roads, the Chief Engineer has every reason for making a public acknowledgement of their faithful and valuable services.
>
> To the superintendent and officers composing the staff of the Military Academy, he takes great pleasure in expressing his sense of their enlightened and successful exertions, to elevate and maintain the character of that valuable institution.
>
> And to the members of the board of engineers for fortifications, and internal improvements, too much praise cannot be given for the industry and intelligence with which they have discharged the important and arduous duties committed to them.

> In closing this order, the Chief Engineer cannot refrain from stating with proud satisfaction the fact, that during the period for which he has presided over the department, no loss has been occasioned to the public by any defalcation or neglect on the part of its officers, especially when it is considered that the amount of six millions of dollars has been disbursed in small sums and for items of a nature that require the greatest care and attention to satisfy the strictness of the accounting officers, and to comply with the established regulations of the department.
>
> The major-general will never cease to take a great interest in the success and prosperity of the Engineer Department, and will, so far as it may be in his power, lend his aid to promote its usefulness, and, if possible, to increase its consideration in the public estimation.
>
> ALEXANDER MACOMB,
> *Maj. Gen., Chief Engr. of the U. S.*

General Macomb was succeeded as colonel and Chief Engineer by Lieut. Col. Charles Gratiot, of the Corps of Engineers.

On the 22d of June, 1831, by a regulation of the War Department, the Topographical Bureau of the Engineer Department was constituted a distinct Bureau of the War Department, and the officer in charge thereof, was directed to communicate directly with the Secretary of War, from whom he was to receive all his orders, and to whom he was to make all his reports.

On the 10th of August, 1831, Bvt. Brig. Gen. Simon Bernard, assistant engineer, resigned his office, and returned to France, Col. James Gadsden being appointed "Assistant engineer" by the President, in his place. This office was discontinued October 1, 1832, by virtue of the joint resolution of Congress of July 14, 1832.

By the act of July 5, 1838, to increase the present military establishment of the United States, and for other purposes it was enacted:

> SEC. 2. That the President of the United States be, and he is hereby, authorized to add to the Corps of Engineers, whenever he may deem it expedient to increase the same, one lieutenant-colonel, two majors, six captains, six first and six second lieutenants, and that the pay and emoluments of the said corps shall be the same as those allowed to the officers of the regiment of dragoons.
>
> SEC. 3. That so much of the act passed the twenty-ninth day of April, 1812, entitled "An act making further provision for the Corps of Engineers," as provides that one paymaster shall be taken from the subalterns of the Corps of Engineers, be, and the same is hereby, repealed, and that the paymaster so authorized

> and provided be attached to the Pay Department, and be in every respect placed on the footing of other paymasters of the Army.
>
> SEC. 27. That it shall be the duty of the engineer superintending the construction of a fortification, or engaged about the execution of any other public work, to disburse the moneys applicable to the same, and as a compensation therefor may be allowed by the Secretary of War at the rate of two dollars per diem during the continuance of such disbursements: *Provided*, That the whole amount of emolument shall not exceed one per cent. on the sum disbursed.

But by the act of July 7, 1838, it was provided:

> That no compensation shall be allowed to officers of the Engineer Department for disbursement of public money while superintending public works.

On the 6th of December, 1838, Col. and Bvt. Brig. Gen. Charles Gratiot was dismissed the service by an order of the President. This dismissal of General Gratiot arose from his refusal to settle his accounts in accordance with the decisions of the Comptroller of the Treasury, which General Gratiot believed were not in accordance with law. He was succeeded in the office of Chief Engineer by Lieut. Col. Joseph G. Totten, Corps of Engineers.

In accordance with the instructions of the Secretary of War of Augsut 1, 1838, there were transferred, by the 18th of June, 1839, to the corps of Topographical Engineers, organized the preceding year, some seventy or more works of improvement of harbors and rivers along the Gulf, Atlantic, and Lake coasts.

By the act of May 15, 1846, for the organization of a company of sappers, miners, and pontoniers, it was provided:

> That there be added to the Corps of Engineers one company of sappers, miners, and pontoniers, to be called engineer soldiers; which company shall be composed of ten sergeants, or master-workmen, ten corporals, or overseers, two musicians, thirty-nine privates of the first class, or artificers, and thirty-nine privates of the second class, or laborers; in all, one hundred men.
>
> SEC. 2. That the pay and rations of the sergeants, or master-workmen, of said company shall be the same as those now allowed by law to the master-workmen employed by the ordnance department, excepting that the engineer sergeants shall receive one ration only per day instead of one ration and a half; of the corporals, or overseers, the same as those now allowed by law to the armorers, carriage-makers, and blacksmiths employed by the ordnance department, excepting that the engineer corporals shall receive one ration only per day, instead of one ration and a half;

> of the privates of the first class, or artificers, the same as those now allowed by law to the artificers employed by the ordnance department; of the privates of the second class, or laborers, the same as those now allowed by law to the laborers employed by the ordnance department, and of the musicians the same as those allowed by law to the musicians of the line of the Army; the said non-commissioned officers, privates, and musicians being, respectively, entitled to the same clothing and other allowances as are granted by law to non-commissioned officers, privates, and musicians of the artillery of the Army of the United States.
>
> SEC. 3. That the said engineer company shall be subject to the rules and articles of war, shall be recruited in the same manner and with the same limitation, and shall be entitled to the same provisions, allowances, and benefits in every respect, as are allowed to the troops constituting the present military peace establishment.
>
> SEC. 4. That the said engineer company shall be attached to and compose a part of the Corps of Engineers, and be officered by officers of that corps, as at present organized; they shall be instructed in and perform all the duties of sappers, miners, and pontoniers, and shall aid in giving practical instructions in these branches at the Military Academy; they shall, moreover, under the orders of the Chief Engineer, be liable to serve by detachments, in overseeing and aiding laborers upon fortifications or other works under the Engineer Department, and in supervising finished fortifications as fortkeepers, preventing injury and applying repairs.
>
> SEC. 5. That the Chief Engineer, with the approbation of the Secretary of War, be authorized to regulate and determine the number, quality, form, dimensions, &c., of the necessary vehicles, pontons, tools, implements, arms, and other supplies for the use and service of said company as a body of sappers, miners, and pontoniers.

This company was recruited, drilled, and organized by the last of September, 1846, and was at once ordered to join General Taylor's command, arriving at Brazos Santiago on the 11th of October. It served in the siege of Vera Cruz, and participated in all the subsequent operations towards the city of Mexico until its capture, and remained in the country until its evacuation by our armies.

Twenty officers of the Corps of Engineers, including the Chief Engineer, served with distinction in Mexico during the war with that country.

By the act of March 3, 1851, it was enacted:

> That the President be, and he is hereby, required to cause to be detailed from the Engineer Corps of the Army, from time to

time, such officers as may be necessary to superintend the construction and renovating light-houses.

By the act of August 31, 1852, making appropriations for light-houses, &c., &c., a Light-House Board was constituted, and provision made that three of its members should be officers of engineers.

The connection of engineer officers with the construction of our light-houses dates back as far as 1831, at which time certain moneys appropriated for lights upon the lakes were placed by the Treasury Department in the hands of officers of the engineers for disbursment, and from that period, to the organization of the Light-House Board, there were always a number of engineer officers engaged on this duty —the construction, by law, in some cases, having been directed to be in the hands of the engineers.

By the act of March 3, 1853, it was directed:

> That whenever any lieutenant of the Corps of Engineers, Corps of Topographical Engineers, or Ordnance shall have served fourteen years' continuous service as lieutenant he shall be promoted to the rank of captain: *Provided*, That the whole number of officers in either of said corps shall not be increased beyond the number now fixed by law.

By the act of August 3, 1861, it was provided:

> SEC. 3. That there shall be added to each of the Corps of Engineers and Topographical Engineers, three first and three second lieutenants, to be promoted thereto in accordance with the existing laws and regulations.
>
> SEC. 4. That there shall be added to the Corps of Engineers three companies of engineer soldiers, to be commanded by appropriate officers of said corps, to have the same pay and rations, clothing, and other allowances, and to be entitled to the same benefits in every respect as the company created by the act for the organization of a company of sappers and miners and pontoniers, approved May 15, 1846.
>
> * * * * * * *
>
> And each of the four companies of engineer soldiers shall hereafter be composed of ten sergeants, ten corporals, two musicians, sixty-four privates of the first class, or artificers, and sixty-four privates of the second class—in all, one hundred and fifty men.

By the act of August 6, 1861, it was provided:

> That there shall be added to each of the Corps of Engineers and Topographical Engineers, by regular promotion of their present officers, two lieutenant-colonels and four majors.

By the act of March 3, 1863, it was provided:

> That the Corps of Topographical Engineers, as a distinct branch of the Army, is hereby abolished, and from and after the passage of this act is merged into the Corps of Engineers, which shall have the following organization, viz: One Chief Engineer, with the rank, pay, and emoluments of a brigadier-general; four colonels, ten lieutenant-colonels, twenty majors, thirty captains, thirty first lieutenants, and ten second lieutenants.
>
> SEC. 2. That the general officer provided by the first section of this act shall be selected from the Corps of Engineers, as therein established, and that officers of all lower grades shall take rank according to their respective dates of commission in the existing Corps of Engineers or Corps of Topographical Engineers.
>
> SEC. 3. That no officer of the Corps of Engineers below the rank of field-officer shall hereafter, be promoted to a higher grade before having passed a satisfactory examination before a board of three engineers senior to him in rank; and should the officer fail at such examination, he shall be suspended from promotion for one year, when he shall be re-examined, and, upon a second failure, shall be dropped by the President from the Army.

Under the operations of this act, Col. Joseph G. Totten was appointed Chief Engineer and Brigadier-General, Corps of Engineers.

On the 22d of April, 1864, Brig. Gen. and Bvt. Maj. Gen. Joseph G. Totten, Chief Engineer, U. S. A., died, and was succeeded by Col. Richard Delafield, Corps of Engineers, in that office.

By the act of June 20, 1864, it was provided:

> SEC. 4. That there be added to the Battalion of Engineers, one sergeant-major, who shall be paid thirty-six dollars per month, and one quartermaster-sergeant, who shall also be commissary-sergeant, who shall be paid twenty-two dollars per month.

During the civil war the Corps of Engineers was actively engaged, both upon staff duty with the troops in the field, and as officers of volunteers in command of troops.

Thirty-three officers, who either held or had held commissions in the Corps of Engineers, were appointed General Officers in command of troops. Of these, three became major-generals, and three brigadier-generals, in the Regular Army; fifteen were major-generals of volunteers, and twelve, brigadier-generals of volunteers; eight, of the thirty-three, commanded Armies, and ten others Army Corps. At least eight general officers, in the confederate armies, had been officers of the Corps of Engineers.

By the act of July 13, 1866, it was provided:

> SEC. 6. That the Superintendent of the United States Military Academy may hereafter be selected, and the officers on duty at that institution detailed, from any arm of service, and the supervision and charge of the academy shall be in the War Department, under such officer or officers as the Secretary of War may assign to that duty.

In compliance with this law, the supervision and charge of the Military Academy passed from the Corps of Engineers to the War Department, and the superintendency from the exclusive detail of officers of engineers. Upon the promulgation of this law, the following order was issued by the Chief Engineer:

> In conformity with the act of Congress approved July 13, 1866, and with general orders from the War Department of the 30th of July, 1866, the control and management of the United States Military Academy, have passed from the Corps of Engineers.
>
> Sixty-four years have elapsed since the academy, conceived by Washington in the last century, was established, (in 1802,) at West Point and committed by President Jefferson to the fostering care of the Corps of Engineers as a special school for that arm. While keeping in view the original object, the thorough scientific military education of engineers, the corps has not failed to recognize the larger demands of the nation made upon the academy from time to time by the results of experience in war, and study and observation in peace. In 1812 it accordingly developed and adapted the academy to meet the wants of all branches of the military service, so far as one institution can supply them. Upon the fundamental principles then established, it has conducted the academy to the present time, shaping and perfecting it to meet its special functions, and to keep pace with the advancement of science and art, and the corps may now, in parting with it, confidently ask that the tree may be judged by its fruits.
>
> The battle-fields of every war from 1812 to the suppression of the late rebellion, and the ever-recurring conflicts with the savage tribes, speak plainly of the ability and gallantry of the graduates of the academy, and the walks of honor and usefulness in the various fields of pubilc and private civil life have been adorned by its elèves.
>
> Under the sanction of law the academy ceases to have any special connection with the Corps of Engineers. In announcing this fact to his officers, the Chief Engineer enjoins it upon them to give hereafter, as they have done heretofore, their best efforts for the continued prosperity and success of the academy, and to contribute all in their power to aid those to whom it may henceforth be confided.
>
> RICHARD DELAFIELD,
> "*Bvt. Maj. Gen. and Chief Engineer, U. S. A.*"

By the act of July 28, 1866, to increase and fix the military peace establishment of the United States, it was provided:

> SEC. 19. That the Corps of Engineers shall consist of one Chief of Engineers, with the rank, pay, and emoluments of a brigadier general, six colonels, twelve lieutenant-colonels, twenty-four majors, thirty captains, and twenty-six first and ten second lieutenants, who shall have the pay and emoluments now provided by law for officers of the Engineer Corps.
>
> SEC. 20. That the five companies of engineer soldiers and the sergeant-major and quartermaster-sergeant, heretofore prescribed by law, shall constitute a battalion of engineers to be officered by officers of suitable rank detailed from the Corps of Engineers; and the officers of engineers, acting respectively as adjutant and quartermaster of this battalion, shall be entitled to the pay and emoluments of adjutants and quartermasters of cavalry.

Upon the 8th of August, 1866, Brig. Gen. and Bvt. Maj. Gen. Richard Delafield, Chief of Engineers, was retired from active service, by direction of the President, and was succeeded in the office of Chief of Engineers by Lieut. Col. Andrew A. Humphreys, Corps of Engineers, brevet major-general, United States Army.

By the act of February 12, 1867, the pay and allowances of the quartermaster-sergeant of the battalion of engineers were fixed as the same as those allowed to the sergeant-major of the battalion.

By the act of March 2, 1867, it was provided:

> SEC. 2. That the office of Commissioner of Public Buildings is hereby abolished, and the Chief Engineer of the Army shall perform all the duties now required by law of said Commissioner, and shall also have the superintendence of the Washington Aqueduct, and all the public works and improvements of the Government of the United States in the District of Columbia unless otherwise provided by law.

And by the act of March 29, 1867, it was enacted:

> SEC. 7. That the several sums of money heretofore appropriated to be expended under the direction of the Commissioner of Public Buildings be transferred to, and may be expended under the direction of, the Chief Engineer of the Army, or such officer of the Engineer Corps as he may direct.

By the act of March 3, 1869, it was enacted:

> SEC. 6. That until otherwise directed by law there shall be no new appointments and no promotions * * in the Engineer Department. * * *

By the act of July 15, 1870, sec. 2, the President was directed to reduce the number of enlisted men in the Army to thirty thousand, the reduction to be effected by the 1st of July, 1871. Under the operations of this law the Battalion of Engineers was reduced to 354 enlisted men, and four organized companies, the fifth being retained as a skeleton only.

By the act of January 10, 1872, it was provided:

> That so much of section six of an act entitled ''An act making appropriations for the support of the Army for the year ending June thirtieth, eighteen hundred and seventy, and for other purposes,'' approved March third, eighteen hundred and sixty-nine, as prohibits promotions and new appointments in the Engineer department, be, and the same is hereby, repealed: *Provided*, That nothing herein contained shall authorize promotion in said Department above the grade of colonel.

By the act of February 1, 1873, it was provided:

> That the enlisted men of engineers in the Army, are hereby placed on the same footing, with respect to compensation for extra-duty service, as the other enlisted men of the Army, and that all laws or parts of laws in conflict with this provision be, and the same are hereby, repealed.

By the act of June 16, 1874, making appropriation for the support of the Army for the year ending June 30, 1875, it was provided that the number of enlisted men in the Army, including Indian scouts, but excluding the Signal Service, should not exceed 25,000 men. Under the operations of this law the number of enlisted men authorized in the Battalion of Engineers was reduced to 200, and the companies organized to four.

By the act of June 20, 1874, for the government of the District of Columbia, and for other purposes, it was provided:

> SEC. 3. That the President of the United States shall detail an officer of the Engineer Corps of the Army of the United States, who shall, subject to the general supervision and direction of the said board of commissioners, have the control and charge of the work of repair and improvement of all streets, avenues, alleys, sewers, roads, and bridges of the District of Columbia; and he is hereby vested with all the power and authority of, and shall perform the duties heretofore devolved upon, the chief engineer of the board of public works. * * *

HISTORICAL SKETCH OF THE CORPS OF TOPOGRAPHICAL ENGINEERS.

As the Corps of Topographical Engineers and its troops were united with the Corps of Engineers in 1863, it is proper that mention should be made of the organization, in the Army of the Revolution, which performed those duties in after years devolved, as a portion of their functions, upon the Corps of Topographical Engineers of the Army.

The resolutions of July 25, 1777, first authorized the appointment in the Army of such officers as follows:

> *Resolved*, That General Washington be empowered to appoint Mr. Robert Erskine, or any other person that he may think proper, geographer and surveyor of the roads, to take sketches of the country, the seat of war, and to have the procuring, governing, and paying the guides employed under him, the General to fix the pay of the said geographer, &c., and the allowance that shall be made to the guides.

On December 4, 1780, the following resolution was passed:

> *Resolved*, That Mr. Simeon De Witt be appointed geographer to the Army, in the room of Robert Erskine, deceased.

On July 11, 1781, the following resolution was passed:

> *Resolved*, That the geographer to the main Army, and also the geographer to the southern army, be styled "Geographer to the United States of America," and commissioned and considered as such, and that they perform such service as the Commander-in-Chief, and commanding officer of the southern army may judge necessary to assign them respectively.

On November 12, 1782, the following action was taken in Congress:

> Whereas, no provision has been made by Congress for the geographers to the Armies of the United States: Therefore,
>
> *Resolved*, That the geographer to the main Army, and the geographer to the southern department, be each of them allowed $60 per month, three rations per day, forage for two saddle-horses, one two-horse covered wagon, six and two-thirds dollars per month for a servant, for whom they shall be entitled to draw one ration per day, and the clothing allowed to a private soldier; that the assistant geographers, if such officers shall be judged necessary by the Commander-in-Chief, be allowed $30 per month, one ration per day, and forage for one saddle-horse; that when chain-bearers shall be employed, not being soldiers, they shall each be allowed half a dollar per day.

The compensations given above, were those which pertained to the grades in the Army, of colonel and captain respectively.

Upon the close of the war and the disbanding of the Army, the geographer of the United States was continued in office as surveyor of the public lands, as appears from the following resolutions:

MAY 27, 1785.

> *Resolved*, That the geographer of the United States be continued in office for a term not exceeding three years, and that he be allowed during his continuance in office, six dollars per day, for his services and expenses.

JUNE 9, 1785.

> *Resolved*, That the Board of Treasury advance to Thomas Hutchins, geographer of the United States, $700 on account.
>
> That the Board of Treasury advance Thomas Hutchins, geographer of the United States $6,000, for which he is to be accountable, to be applied by him, from time to time, to the use of the several officers concerned in carrying into execution, the ordinance for ascertaining the mode of disposing of lands in the western territories.

After the establishment in 1794 of a corps of artillerists and engineers, and the formation by them of a school at West Point, the necessity of topographical engineers in our service, was recognized in the War Department, as will appear from the following extract from some notes furnished the Committee on the Military Establishment in Congress, by Col. Timothy Pickering, late Secretary of War, dated February 3, 1796:

* * * * * * *

> The corps of artillerists and engineers appears to be an important establishment. To become skillful in either branch of their profession will require long attention, study, and practice, and because they can now acquire the knowledge of these arts advantageously only from the foreign officers, who have been appointed with a special reference to this object, it will be important to keep the corps together for the present, as far as the necessary actual service will permit. Its principal station may then become a school for the purpose mentioned. To render this school more complete, provision is wanting *for a geographical engineer and draughtsman*. Such a one may now be retained for the establishment of a captain.

No officers with the special functions of topographical engineers were, however, provided for our armies until the early part of the war of 1812 with Great Britain, when Congress by an act for the better organization of the general staff of the Army, passed March 3, 1813, made provision for eight topographical engineers and as many assistants, the former to have the brevet rank of majors, the latter of brevet captains; the topographical engineers to be taken from the line, or not, as the President might deem expedient, the assistants to be taken from the line; and any officers taken from the line and transferred to the staff, to receive only the pay and emoluments attached to their rank in the staff, but their transfer to be without prejudice to their rank and promotion in the line according to their said rank and seniority.

The President, under the authority of this law, made the following appointments, viz:

Topographical Engineers.

	Appointed.	Rank in line.
Major John Anderson	April 12, 1813.	Capt. 19th Infantry.
Major Paul H. Perrault	April 12, 1813.	
Major Isaac Roberdeau	April 29, 1813.	
Major Simon Z. Watson	August 3, 1813.	

Assistants.

	Appointed.	Rank in line.
Captain Thomas Clark	April 1, 1813.	2d Lieut. 2d Artillery.
Captain James Kearney	April 12, 1813.	3d Lieut. 5th Infantry.
Captain Daniel Rose	July 20, 1813.	3d Lieut. 21st Infantry.
Captain Benjamin Connor	August 3, 1813.	3d Lieut. 1st Artillery.

Of these officers, Major Anderson and Roberdeau, and Captains Clark, Kearney, and Rose were assigned to the northern division of the Army, and Majors Perrault and Watson, with Captain Connor, to the southern, under the following instructions published in May, 1813:

Duties of Topographical Engineers and their assistants.

> To make such surveys, and exhibit such delineations of these as the commanding-general shall direct; to make plans of all military positions (which the Army may occupy) and of their respective vicinities, indicating the various roads, rivers, creeks, ravines, hills, woods, and villages to be found therein; to accompany all reconnoitering parties sent out to obtain intelligence of the movements of the enemy or of his position, &c.; to make sketches of their route, accompanied by written notes of everything worthy of observation thereon; to keep a journal of

> every day's movements, when the Army is on march, noticing the varieties of ground, of buildings, of culture, and the distances and state of the road between given points throughout the march of the day, and, lastly, to exhibit the positions of contending armies on fields of battle, and the disposition made, whether for attack or defense.

Major Watson died the 1st of February, 1814, and the appointment of Benjamin Connor as captain was negatived by the Senate in March of 1814. On the 1st of January, 1815, the Topographical Department consisted of the following officers, to-wit:

Major John Anderson; Major Paul H. Perrault; Major Isaac Roberdeau; Major J. C. Warren, appointed 30th of March, 1814; Major John J. Abert, appointed 22d of November, 1814; Captain Thomas Clark; Captain James Kearney; Captain Daniel Rose; Captain Gamaliel Pease, appointed 15th of July, 1814, second lieutenant, First Infantry.

And the new appointments were attached to the southern division of the Army.

In the year 1815, and until the termination of the war, the same officers remained in service. On the conclusion of peace under the Treaty of Ghent, and the consequent hasty reduction of the Army at the close of the session of Congress, the Topographical Engineers being considered as exclusively appertaining to the general staff, were unprovided for by the act affixing the military peace establishment passed on the 3d of March, 1815, and were mustered out of service June 15, 1815. This act, however, authorized the President provisionally to retain certain officers whose services might be of importance, and who might not be included in the details of the law.

As the reports of the Topographical Engineers stationed on the frontiers were made to commanding generals of divisions or detachments, under circumstances unfavorable to a perfect and minute delineation of the objects of their attention, the peace found them in an unfinished state, although the notes and sketches of many parts of the country had been obtained with much labor and preserved with care. This circumstance being reported to the President, as well as the importance on every other consideration of retaining this branch of the Army on the peace establishment, when the duties that would necessarily be assigned to it could be with better success pursued, he, on the 19th of June, 1815, retained two majors, Anderson and Roberdeau, who were directed, under special orders from the War

Department, to complete the surveys on the northern frontier and Lake Champlain, with some other matters which the unexpected close of the war had suspended, and to report to the Chief Engineer, General Swift, for the execution of this duty.

These duties were performed, but, by extending those surveys and geological researches, the importance of the continuance of the corps was proportionally increased, and the succeeding Congress found them still more deeply engaged in these useful investigations than during the late war they were permitted advantageously to pursue.

As the authority of Congress was necessary to the re-establishment of the corps, and presuming that sufficient information had not been imparted to lead to a true knowledge of its usefulness, and proper attention in the time of peace as well as of war, the following memoir was prepared with a view of directing the attention of Congress to the subject, as one of much importance in the development of the civil as well as military resources of the nation:

Memoir.

Engaged in the execution of duties, the importance of which on a large scale appears not yet to be sufficiently appreciated, it would be deviating from the practice of all topographers not to present such views of the performance of their functions in the public service as are important to the nation, and which the particular circumstances of the country and the infancy of this branch of public economy so forcibly impress as a military and civil or political duty.

The undersigned have in the course of the war had to perform necessary services in the Topographical Departments at different points; at the close of the contest, they had, conjointly, to make topographical surveys where the want of accurate information had been felt in the progress of it, and which would be again experienced should war at any future period be renewed.

Under an order of June last, with which the undersigned were honored by the President of the United States, a considerable portion of the northwestern and western Territories has been critically explored by them. As much of this reconnoiter as the limited time since their return would admit of, has been hastily sketched, which, together with the different detailed reports on the subject, have been transmitted to General Swift. The intention, therefore, of this memoir is merely the reflections which their sense of duty imposes upon them to offer, with the utmost deference, to the chief of the Department, for the consideration of the President of the United States.

The duties of the topographical department of an army embrace a variety of subjects; the views of ground and the facilities for movements of every kind; the profiles of positions and the routes which are, or may be, opened are usually considered by those who have not entered into the spirit of the science as comprehending the whole of its duties. But a great portion of topographical research would be lost to the public were its functions so limited or were they confined to the mere selection for sites of camps or fields of action. It becomes, therefore, the duty of those who have been honored with public confidence in this department, if they have not the opportunity of carrying into operation the functions of their immediate stations on that scale or to that extent which the present deficiency of this kind of information so imperiously calls for, that they should at least point out what they conceive to be necessary for the strength of the country, for knowledge is in no case so really identified with strength as in the knowledge of the country, which is our own, where it is weak and open to assault, where it is defensible, and, in short, where its resources in a military view are feeble, and where and how susceptible of defense.

It is in this point of view that it becomes associated with the engineers of fortification. It is here that their functions sustain and perfect each other; and it is in this view that it will be best seen how necessary the subdivision of the science, like the subdivision of labor, contribute to the perfection of each other and of the whole.

The engineers of works operate on fixed positions; their duties may be considered sedentary, while the topographer has to trace the routes, not only of the army to which they belong, but to preoccupy, reconnoiter, and know every route by which an enemy may approach. Under this view of their respective duties, among others equally impressive, the expediency of placing both departments under one chief is, with great deference, submitted.

But yet these are not all the duties which properly belong to the Topographical Department. Much of its utility would be thrown away if their functions commenced and ceased with immediate military action. It is through this department that the experience of a campaign past is rendered subservient to future ones, or that the same duties are not to be performed in detail on the same subjects with every new army. The recording topographical details for future use, is one of the great economical functions of this department.

Nor does it cease here; the same intelligence which surveys the roads and ravines, the hills, woods, valleys, and declivities, the morasses, and mounds, which so much influence military operations and often decide the fortunes of war, requires the association of other inquiries, which bear analogy to statistical science, and which renders that branch of knowledge a necessary part of military record. A numerous population, in a country which is to become the theater of operations, present many considerations which may produce very different results from those presented by a simple description, or the most minute details of the ground. The knowledge of the condition, as well as numbers of the population, comes within the same scope; a fertile or a sterile country, even the temper, dispositions, and habits of the people, their mode of life, their food, stock, and civil condition in relation to their own government, become a part of the objects upon which the topographer has to report, because without these a knowledge of the ground alone would be insufficient.

Under such views, it may be perceived that it is of the utmost moment to render the circle of the duties of this branch as complete as possible; that its records should present a sort of civil history, as well as a picturesque detail, and the more perfect these several branches are combined and developed the greater will be the advantage to the country.

The immediate objects of the present memoir are the surveys and reconnoiter executed by the undersigned within the past year, a part of which, with reports on some of the subjects, have been presented to Brigadier-General Swift. They embrace topographical surveys and views of detached points only, but these of great importance with a view to future precaution. The first contains surveys on the Champlain frontier; the second, surveys on the Cadaraqui; a third of Oswego, on Lake Ontario; and the fourth on the scenes of those brilliant operations which have rendered both shores of the Niagara Strait memorable in our annals. Of these several objects drawings have been prepared, though not in that complete and finished state which their importance demands. But the field-notes and sketches are so ample and minute, as to require only the necessary time and labor, to place them in a state that will not be inferior in usefulness to those of any other nation. The drawings and field-notes of Mackinaw and Detroit are equally minute, and require time only to arrange them perfectly.

In some of those surveys it has presented to our reflection, that the positions which have been established in former wars between France and England were selected with very great skill, so much so, that were the country to be settled anew, by a scientific people, the same sites would be preferred to any others which are contiguous to them. Among these may be pre-eminently noticed Crown Point, Kingston in Canada, Oswego, and Niagara, in the State of New York, all which were originally selected by the French, and improved, or occupied subsequently by the British.

Upon commencing a topographical tour on the waters of Lake George, on the route to Champlain, the principal point which presented itself to our consideration was Crown Point. The idea of General Lloyd, though crude in its details, was very sound in its design; that of operations by Lake Champlain and

Albany, so as to separate the Eastern from the Middle States by the Hudson. It was attempted by Burgoyne, and menaced, with equal futility, by Prevost, in the late war. Independently of those political causes which have existed, and may yet exist, to encourage the renewing of such a design, (for nations, like individuals, are often disposed to retrieve disasters upon the very ground on which they suffered,) Crown Point appears to have been not duly regarded in the late war, for it presents the best position for a depot, with all the advantages of military defense.

These views, which might be enlarged to a voluminous extent, are respectfully submitted as evidences of what may be accomplished in a short period, by attentions well directed and employed. But the field-notes and sketches are valuable, both from their accuracy and minuteness, and because, above all, they are the fruit of great toil, which toil must be renewed on the same subjects should any future war arise, if the knowledge now possessed be not profitably used.

The undersigned do not hesitate to recommend, without the apprehension of being mistaken, or of its being attributed to any other than public motives, the completion of a frontier military survey of the whole interior and exterior of the United States. This work, together with the duties necessarily arising out of the survey of the sea-coast, and the establishment of the boundary-line between the United States and the British Provinces in Canada, can be executed with the best effect by a Corps of Topographical Engineers, under the immediate direction of the Chief of the Engineer Corps, and by them, with the employment of the military, at much less expense than that which these duties could be obtained from persons employed out of civil life in those services.

All which is respectfully submitted.

JOHN ANDERSON,
Topographical Engineer.

I. ROBERDEAU,
Major, Topographical Engineers.

The Hon. WILLIAM CRAWFORD,
Secretary of War.

WASHINGTON, *January 16, 1816.*

By the act of April 24, 1816, for organizing the general staff, and making further provisions for the Army of the United States, three Topographical Engineers, and two assistants were provided for each division, which re-established the corps to its former numbers and rank, still connecting it with the general staff of the Army.

The corps formed under this arrangement consisted of the following officers:

Major John Anderson, to rank from April 12, 1813; Major Isaac Roberdeau, to rank from April 29, 1813; Major John J. Abert, to rank from November 22, 1814; Major James Kearney, appointed April 29, 1816; Major Stephen H. Long, appointed April 29, 1816; Major John Wilson, appointed April 29, 1816.

There were no assistant Topographical Engineers appointed at this time. Of the above officers, Majors Anderson, Roberdeau, and Abert were attached to the northern, and Majors Kearney, Long, and Wilson to the southern division of the Army.

The Board of Engineers for Fortifications having been organized in November of 1816, several officers of the Topographical Engineers were at once attached to the board for the purpose of making the necessary surveys. By the close of 1817 the following officers of Topographical Engineers had been detailed for duty with this board:

Major Isaac Roberdeau, Major John J. Abert, Major James Kearney, Captain William T. Poussin, aid-de-camp to General Bernard.

On the 2d of July, 1818, the following General Order, dated Adjutant and Inspector General's Office, was issued:

> The Topographical and assistant Topographical Engineers are arranged to the Engineer's Department, and are made subject to the orders of the chief and commanding engineers.
>
> When orders or instructions are given to such as are now attached to the command of any general, the communication will be made through him.
>
> By order.
>
> DANIEL PARKER,
> *Adjutant and Inspector General.*
>
> NOTE.—I send this to the Adjutant Generals of Divisions.
>
> D. P.

The Topographical Engineers were thus constituted a part of the Engineer Department, and at this time were engaged in explorations in the West, and in surveys along the seaboards for fortifications.

In August, 1818, a Topographical Bureau was established by the War Department, at Washington, and Major Roberdeau was stationed there, to take charge of its arrangement under the immediate direction of the Secretary of War and the Chief Engineer. At this period is to be dated the origin of an institution which has been so important to the future demands of the Government.

By the act of March 2, 1821, to reduce and fix the military peace establishment of the United States, it was provided—

> That the Topographical Engineers and their assistants shall be retained in service as at present organized.

That organization allowed six officers with the rank of brevet major, and four with the rank of brevet captain, which, by the above act, was fixed without regard to the number of divisions or brigades in the Army.

By the act of April 30, 1824, organizing a Board of Engineers for Internal Improvements, the additional duties devolved upon the officers of Topographical Engineers, in the surveys and reconnaissances needed by this board, were of such magnitude, that a large number of officers from the line of the Army, as well as civil engineers, had to be employed.

During the season of 1824, twenty-five officers of the line of the Army, and thirty civilians were employed under the directions of Topographical Engineers upon the various surveys in progress, and from this time to the organization of the Corps of Topographical Engineers, in 1838, about this number of officers and civil-engineer assistants, were annually employed on topographical duty.

After the death of Lieut. Col. Isaac Roberdeau, on the 15th of January, 1829, Lieut. Col. J. J. Abert was ordered to Washington by General Gratiot, to take the charge of the Topographical Bureau of the Engineer Department, and on the 20th of February, 1829, was appointed assistant to the Chief Engineer—

> In relation to such reconnaissances and surveys, both for military and civil purposes, as may be entrusted to Topographical Engineers, assistant Topographical Engineers, or civil engineers, under the direction of the Engineer Department.

On the 10th of June, 1830, the following order, by direction of the Secretary of War, was issued by the Chief Engineer:

> The Board of Engineers for Internal Improvements is hereby organized, to consist of the following officers, viz:
>
> General Bernard, assistant engineer; the Topographical Engineer in charge of the Topographical Bureau of the Engineer Department; such officers of the Corps of Engineers as may be at any time attached to the board by the Chief Engineer.
>
> The engineer or other officer, civil or military, who may have conducted the surveys relative to any project submitted to the

board, will be considered a member of the board during the preparation of the report on such projected work, and for that purpose only.

The board will, as heretofore, report to and receive their orders from the Engineer Department.

Major Poussin will continue to act as assistant to the board.

In consequence of the additional duties hereby assigned to the officer in charge of the Topographical Bureau, that part of engineer order No. 3, dated the 20th of February, 1829, which requires him to perform the duties of assistant to the Chief Engineer in certain cases, is rescinded.

By order of the Secretary of War.

C. GRATIOT,
Brigadier-General.

On the 21st of June, 1831, the following regulation was issued by the War Department:

> 1. The Topographical Bureau will hereafter constitute a distinct bureau of the War Department, and the officer in charge thereof will communicate directly with the Secretary of War, from whom he will receive all his orders and to whom he will make all his reports.
>
> 2. All reports, returns, and communications from officers of the Topographical Engineers, or others on topographical duty, will hereafter be made to the officer in charge of the Topographical Bureau, through whom, in addition to his previous duties, all orders to officers of the Topographical Engineers, or others on topographical duty, will hereafter pass.
>
> 3. The officer in charge of the Topographical Bureau will comply with any application from the Chief Engineer for any original document in said bureau, or for copies of the same, and for surveys for purposes of fortifications.
>
> P. G. RANDOLPH,
> *Acting Secretary of War.*

By the act of July 5, 1838, to increase the present military establishment of the United States and for other purposes, it was enacted:

> SEC. 4. That the Corps of Topographical Engineers shall be organized and increased by regular promotions in the same, so that the said corps shall consist of one colonel, one lieutenant-colonel, four majors, ten captains, ten first lieutenants, and ten second lieutenants.
>
> SEC. 5. That vacancies created by said organization over and above those which can be filled by the present corps, shall be taken from the Army, and from such as it may be deemed advisable of the civil engineers employed under the act of the

> 30th of April, 1824; that the pay and emoluments of the officers of said corps shall be the same as are allowed to officers of similar rank in the regiment of dragoons.
>
> SEC. 6. That the authority to employ civil engineers in the act of the 13th of April, 1824, be and the same is hereby repealed after the passage of this act.

Under the operations of this act, Brevet Lieut. Col. J. J. Abert, Topographical Engineers, became colonel of the Corps of Topographical Engineers, and from this time the works of rivers and harbors and roads, and other works assigned to the corps for construction, were largely increased.

During the Mexican war some twenty officers of the corps served with distinction in the armies operating in that country.

The act of March 3, 1851, causing details of engineer officers to be made by the President, for the purpose of superintending the construction and renovating light-houses, as well as the act of August 31, 1852, creating a Light-House Board, applied to the Corps of Topographical Engineers, and its officers were detailed equally with the officers of the Corps of Engineers upon that duty.

By the act of August 3, 1861, three first and three second lieutenants were added to the corps, and by the act of August 6, 1861, there were added, by regular promotion to the corps, two lieutenant-colonels and four majors.

Section 2 of this act further provided:

> That there shall be added to the Corps of Topographical Engineers one company of soldiers, to be commanded by appropriate officers of said corps, to have the same pay and rations, clothing, and other allowances, and to be entitled to the same benefits in every respect, as the company created by the act for the organization of a company of sappers and miners and pontoniers, approved May 16, 1846. The said company shall be subject to the rules and articles of war, and shall have the same organization as the companies of engineer soldiers attached to the Corps of Engineers.

On the 9th of September, 1861, Colonel J. J. Abert was retired from active service, and was succeeded as colonel, Corps of Topographical Engineers, by Lieut. Col. Stephen H. Long, of that corps.

By the act of March 3, 1863, the Corps of Topographical Engineers was merged in the Corps of Engineers, producing an organization that would seem to have been contemplated by Majors

Anderson and Roberdeau, the senior officers of this corps, in their memorial of January 16, 1816.

GENERAL REMARKS.

The above historial sketches of the Corps of Engineers have touched mainly upon the laws and regulations which have governed their organizations and administrations in the Army of the United States, but no history of the Corps of Engineers could be complete that did not relate somewhat in detail the labors they have performed.

To do this would require a more extended paper than the time which can be given to this report will admit.

From the earliest period, the several organizations of engineers which we have had in our service, have invariably and exclusively made the surveys for, and the plans of, our seacoast defenses, whether of the temporary character which were built up to 1818, or of the permanent character which have been since that time projected, and have superintended their construction and the disbursement of the funds appropriated by Congress for the same.

Up to about 1831, its officers were to a great degree the repositors, in this country, of that knowledge which was requisite for the purpose of making accurate surveys. The location and construction of the roads, canals, and bridges built for the development of the resources of the country, and the accurate methods of surveying, geodetic, topographic, and hydrographic, now in use, are in a great measure due to the talents and labors of its officers.

Almost all the great routes of internal communication in the interests of commerce and speedy transit, now in existence in the country, were first explored, located, and projected by the officers of this corps. The files of the bureau of the corps in Washington, and the congressional documents, are rich in reports upon the works of this character, that have been examined into under authority of law, by the Corps of Engineers.

In the matter of the improvement of rivers and harbors, in the interest of commerce, the Corps of Engineers has had almost the exclusive control, and the information on this subject contained in reports of its officers, from the early years of this century to the present time, now filed in the bureau of the corps, is a monument to its labors, and a most valuable collection of precedents to be used in the future prosecution of such works.

The surveys, examinations, and constructions which have been made by officers of the corps, have not been confined to such matters as are solely in charge of the War Department. From time to time, the State Department, the Navy Department, the Treasury Department, and the Interior Department have employed its officers in the running of boundary lines, and the surveys for the maps necessary to be used in delicate diplomatic negotiations; in the surveys for, and the construction of, dock-yards; the surveys for canal-routes across the Isthmus of Panama; upon astronomical observations in the interests of science; in the survey of the coasts, the planning and construction of light-houses and other fixed aids to navigation; the planning and construction of public buildings, of custom-houses, post-offices, marine hospitals, &c.; and especially in the contsruction of the Capital, the General Post-Office, and the Washington Aqueduct, in this city.

Scarcelv a branch of engineering, whether military or civil, can be mentioned, that has not been improved and expanded by the study and labors of the officers of this corps, so that the anticipations of the Secretary of War, James McHenry, in his communication of January 31, 1800, urging the importance of establishing by law a military academy and a corps of engineers, before quoted in this paper, would seem to have been realized to the letter, in the history of this corps. He says:

> We must not conclude, from these brief observations, that the services of the engineer is limited to constructing, connecting, consolidating and keeping in repair fortifications. This is but a single branch of their profession, though, indeed, a most important one. Their utility extends to almost every department of war, and every description of general officers, besides embracing whatever respects public buildings, roads, bridges, canals, and all such works of a civil nature. I consider, it, therefore, of vast consequence to the United States that it should form in its own bosom, and out of its own native materials, men qualified to place the country in a proper posture of defense, to infuse science into our Army, and to give our fortifications that degree of force, connection, and perfection which can alone counterbalance the superiority of attack over defense.

Tabular list of Chiefs of the Corps of Engineers of the Armies of the United States, from 1774 to 1868.

Name.	Rank.	Title.	Date of appointment.	Where appointed from.
Richard Gridley*	Colonel	Chief Engineer	June —,1775	Massachusetts.
Rufus Putnam*	do	do	Aug. 5,1776	Do.
Lewis du Portail	do	do	July 22,1777	France.
Lewis du Portail	Brig. Gen.	do	Nov. 17,1777	Do.
Lewis du Portail	Maj. Gen.	do	Nov. 16,1781	Do.
Stephen Rochefontaine.	Lieut. Col.	Commander Corps of Artillerists and Engineers.	Feb. 26,1795	——
Henry Burbeck	do	Commander First Regiment Corps of Artillerists and Engineers.	May 7,1798	Massachusetts.
Jonathan Williams	do	Principal Engineer	July 8,1802	Pennsylvania.
Jonathan Williams	do	Chief Engineer	Apr. 19,1805	Do.
Jonathan Williams	Colonel	do	Feb. 23,1808	Do.
Joseph G. Swift	do	do	July 31,1812	Massachusetts.
Walter K. Armistead	do	do	Nov. 12,1818	Virginia.
Alexander Macomb	do	do	June 1,1821	New York.
Charles Gratiot	do	do	May 28,1828	Mo. Territory.
Joseph G. Totten	do	do	Dec. 7,1838	Connecticut.
Joseph G. Totten	Brig. Gen.	do	Mar. 3,1863	Do.
Richard Delafield	do	do	Apr. 22,1864	New York.
Richard Delafield	do	Chief of Engineers	July 13,1866	Do.
Andrew A. Humphreys.	do	do	Aug. 8,1866	Pennsylvania.

*Chief Engineer Grand Army.

Table showing the number of commissioned officers, cadets and enlisted men of Engineers, authorized by several acts of Congress since March 16, 1802.

CORPS OF ENGINEERS.

Date of act.	Brigadier-General, Chief of Engineers.	Colonels, chief engineer.	Lieutenant-colonels.	Majors.	Captains.	First lieutenants.	Second lieutenants.	Assistant engineer.	Cadets.	Sergeant-majors.	Quartermaster-sergeants.	Sergeants.	Corporals.	Musicians.	Artificers.	Privates.	Total commissioned.	Total enlisted.	Aggregate.
March 16, 1802	----	1	1	2	4	4	4	--	4	--	--	--	--	--	----	----	16	4	20
February 28, 1803	----	1	1	2	4	4	4	--	4	--	--	--	--	--	1	18	16	23	39
April 29, 1812	----	1	1	2	6	6	6	--	--	--	--	4	4	5	20	80	22	115	135
April 29, 1816, (resolution)	----	1	1	2	6	6	6	1	--	--	--	4	4	5	20	80	23	115	136
March 2, 1821	----	1	1	2	6	6	6	1	--	--	--	--	--	--	----	----	23	----	23
April 14, 1832, (resolution)	----	1	1	2	6	6	6	--	--	--	--	--	--	--	----	----	22	----	22
July 5, 1838	----	1	2	4	12	12	12	--	--	--	--	--	--	--	----	----	43	----	43
May 15, 1846	----	1	2	4	12	12	12	--	--	--	--	10	10	2	39	39	43	100	143
August 3, 1861	----	1	2	4	12	15	15	--	--	--	--	40	40	8	256	256	49	600	649
August 6, 1861	----	1	4	8	12	15	15	--	--	--	--	40	40	8	256	256	55	600	655
March 3, 1863	1	4	10	20	30	30	10	--	--	--	--	50	50	10	320	330	105	750	855
June 20, 1864	1	4	10	20	30	30	10	--	--	1	1	50	50	10	320	320	105	752	857
July 28, 1866	1	6	12	24	30	26	10	--	--	1	1	50	50	10	320	320	109	752	861
General Order, December 3, 1870	1	6	12	24	30	26	10	--	--	1	1	34	20	8	150	140	109	354	463
Orders June 30, 1874	1	6	12	24	30	26	10	--	--	1	1	20	16	8	80	74	109	200	309

TOPOGRAPHICAL ENGINEERS.

Date of act.	Colonels.	Lieutenant-colonels.	Majors.	Captains.	First lieutenants.	Second lieutenants.	Sergeants.	Corporals.	Musicians.	Artificers.	Privates.	Total commissioned.	Total enlisted.	Aggregate.
March 3, 1813	--	--	8	8	--	--	--	--	--	--	--	16	----	16
March 3, 1815	--	--	2	--	--	--	--	--	--	--	--	2	----	2
April 24, 1816	--	--	6	4	--	--	--	--	--	--	--	10	----	10
July 5, 1838	1	1	4	10	10	10	--	--	--	--	--	36	----	36
August 3, 1861	1	1	4	10	13	13	--	--	--	--	--	42	----	42
August 6, 1861	1	3	8	10	13	13	10	10	2	64	64	48	150	198
March 3, 1863*	--	--	--	--	--	--	--	--	--	--	--	--	----	---

* Corps merged into Corps of Engineers.

THE ORGANIZATION OF THE CORPS OF ENGINEERS.

From the preceeding historical sketch of the Corps of Engineers, and the consideration of the laws which have been enacted concerning it, it is evident that this corps is a military arm of service, the officers of which, by special enactment, are not permitted (when separated from their own troops) to command other troops except by special assignment of the President, and are subject only to his orders when not separated from the command of the Chief of Engineers. The corps does not form a part of the staff of the Army, for it in no case furnishes the Army with the means necessary for its subsistence, comfort, mobility, and action to any greater degree than does the artillery or cavalry In most services it is termed a special arm, and in all services is assigned a place in line of battle.

In our own service, as it was for many years without enlisted soldiers, and the duties of its officers in time of peace took them away from service with troops, it, by regulation, has been styled a "staff corps," a designation not in accordance with our statute law, or the practice of other armies.

It is recommended that its designation should be simply "Corps of Engineers," the legal one, and that the practice which existed till after 1821, of regarding its officers as of the staff, only when assigned to duty with the staff, be restored in service.

DEMANDS OF THE PUBLIC SERVICE IN TIME OF WAR.

The duties required of the Corps of Engineers in time of war consist in planning, tracing on the ground, and superintendence of construction, of all fortifications of whatever nature needed in military operations, and with the planning, laying out, and construction of all works needed in the attack or defense of fortifications. They are also charged with the duty of procuring information concerning the topographical features of the country in which the Army is operating, and with supplying maps of the same, and of the fields of battle; with the selection of positions for camps, fortified or otherwise, and of obtaining information of the enemy's positions, works, and resourses. They have charge of the bridge equipage of the Army, and the construction or destruction of such bridges as are necessary for the operations, whether in advance or retreat. To this end, the engineer troops are officered by officers of the Corps of Engineers, and are instructed and drilled in sapping, mining, and pontoniering in all their details, and form an integral part of the

Army, while those officers of the Corps, not on duty with the troops, may be assigned to the staffs of the commanding generals.

DEMANDS OF THE PUBLIC SERVICE IN TIME OF PEACE.

In time of peace the duties which are devolved upon the Corps of Engineers of our Army by legislative enactment, or by Executive authority, are, much more numerous than the duties required of engineers serving with armies in the field, although many of the duties incident to time of peace, have still to be continued in time of war.

It is difficult to enumerate all the duties which may have been, or which can be devolved on the Corps of Engineers in time of peace. As the duties generally are such as require familiarity with the sciences and arts, any duty which the Government needs performed which involves the application of this character of learning, and comes within the professional training of the several members of the corps, may be devolved by the President upon them. The principal duties, however, in time of peace are, the surveys for the planning and construction of the permanent fortifications of the coasts; the surveys for the planning and construction of the works for the improvement of rivers and harbors—whether by dikes, wing-dams, dredging, canals, breakwaters, or removal of obstructions by blasting or otherwise; the planing and construction of the light-houses, beacons, and all fixed aids to navigation; the construction of public buildings and works in charge of the War Department in the District of Columbia, and in other Departments of the Government when assigned to the coprs; the survey of the northern and northwestern lakes; the astronomical determination of boundaries and initial points; the surveys and reconnaissances of the western Territories; the supervision over the construction of bridges across the navigable waters; the instruction of cadets at the Military Academy; service upon the staffs of commanding generals of divisions and departments; and the charge and instruction of engineer soldiers, and their further instruction in the use of torpedoes as an accessory in harbor defenses.

NUMBER, RANK, AND PAY OF OFFICERS AND MEN.

The numbers and rank are fixed by sections 1151, 1154, 1155, Revised Statutes, and by War Department orders of December 3, 1870, and June 30, 1874, issued in accordance with the acts of July 15, 1870, and June 16, 1874, as follows:

SEC. 1151. The Corps of Engineers shall consist of 1 Chief of Engineers, with the rank of brigadier-general, 6 colonels, 12 lieutenant-colonels, 24 majors, 30 captains, 26 first lieutenants, and 10 second lieutenants, and the battalion: *Provided*, That no promotion shall be made to fill any vacancy in said corps above the rank of colonel.

SEC. 1154. The battalion of engineers shall consist of the five companies of engineers now existing, 1 sergeant-major, and 1 quartemaster-sergeant, who shall also be commissary-sergeant.

SEC. 1155. Each company of engineer soldiers shall consist of 10 sergeants, 10 corporals, 2 musicians, and as many privates of the first class, not exceeding 64, and as many privates of the second class, not exceeding 64, as the President may direct.

General Orders, }
No. 122. }
WAR DEPARTMENT,
ADJUTANT-GENERAL'S OFFICE,
Washington, December 3, 1870.

As soon as practicable after the receipt of this order, Companies A, B, C, and E of the battalion of Engineers will be reduced to 83 enlisted men each, having the proper proportions of sergeants, corporals, and first and second class privates, and Company D will be reduced to 10 sergeants and 10 privates.

* * * * * * *

[Memorandum.]

WAR DEPARTMENT, ADJUTANT-GENERAL'S OFFICE,
Washington, June 30, 1874.

The act making appropriations for the support of the Army for the year ending June 30, 1875, approved June 16, 1874, provides that no money appropriated by that act shall be paid for recruiting the Army beyond the number of 25,000 enlisted men, including Indian scouts, and excepting the Signal Service.

The following schedule will be the basis of the organization of the Army for the present, to be varied according to circumstances:

Enlisted men of engineers------------------------------200

* * * * * * *

In accordance with this order the companies were directed to be as follows:

Companies A, E	50 enlisted men each.
Companies B, C	49 enlisted men each.
Company D	0
Non-commissioned staff	2 enlisted men each.
Total	200

The pay and allowances of officers of the Corps of Engineers will be found under the head of Title XIV, chapter 3, Revised Statutes, and are the same, grade for grade, as in the cavalry arm of service.

Section 1280, Revised Statutes, contains the pay of the enlisted men, namely:

	Per month.
Sergeant-major of engineers	$36
Quartermaster-sergeant of engineers	36
Sergeants of engineers	34
Corporals of engineers	20
Musicians of engineers	13
Privates (first class) of engineers	17
Privates (second class) of engineers	13

Under the operations of section 1157, Revised Statutes, Company E, Engineers, is stationed at the Military Academy, West Point, to aid in instruction of cadets.

PROPORTION OF ENGINEERS TO THE OTHER ARMS OF SERVICE.

According to the best authorities, the proper proportion of engineer soldiers for an army containing twenty-five regiments of infantry, say 30,000 men, should be seven companies of engineers, of 150 enlisted men each. This body of engineer soldiers would require three field officers, seven captains, and twenty-one subalterns, to officer it; in all, thirty-one officers—and this estimate is based upon the ordinary field duties of these troops in the Army, no account being taken of the attack by regular approaches upon fortified positions. In this case, the number of engineer troops required would be much greater than the number stated above. The proportions which the several arms of service should bear to each other, vary with the character of the services required of the Army, and the nature of the country in which the Army is operating. In our own service the cavalry and artillery arms are much in excess of the ordinary proportions of those arms to the infantry; but the peculiar character of the service of cavalry in our country, and the great extent of sea-coast, and large number of sea-coast defenses to be garrisoned and kept in order, give to us a greater proportion of artillery than would be necessary for the operations of 30,000 infantry in the field. What is true of the artillery can be also said of the engineer soldiers, who, in addition to their ordinary duties, are also trained in the handling of electrical torpedoes, to be used as obstructions to the entrances of our fortified harbors.

The engineer troops in our service are, by law, a part of the Corps of Engineers; are organized in companies and a battalion, and are officered by the officers of the corps, who are detailed by roster for this service.

As the new appointees in the corps are at once ordered on duty with the battalion, a majority of the officers of the corps have served in these companies from two to five years, either as subalterns, or company commanders, and have obtained that experience of the interior police and detail of duty, with company and battalion organizations, which is considered of so much value to the officer who subsequently may be detailed on staff-duty.

By the third section of the act of May 15, 1846, the organic act creating a company of sappers, miners, and pontoniers, it is provided that this company "shall be entitled to the same provisions, allowances, and benefits in every respect as are allowed to the other troops constituting the present military peace establishment."

No stronger language could be used to establish conditions, that engineer troops, in their tactical organizations, are entitled to the same consideration, and are placed upon the same footing as the infantry, artillery, and cavalry.

In their company and battalion organization, these troops have distinguished themselves in time of war upon the line of battle, and the colors borne by the battalion, have inscribed upon them, the names of twenty-four engagements.

It is therefore suggested, that the designation of "staff troops" applied to them would be a misnomer, and that its adoption for the "Battalion of Engineers" be not authorized in the service.

The number of officers in the Corps of Engineers has not been determined in our service by the ordinary consideration of the relative proportions of the several arms, since a majority of the duties required of them, has no relation whatever to the ordinary operations of an army in the field.

The Secretary of War, John C. Calhoun, in his communication to the House of Representatives, December 11, 1818, concerning the proposed reduction of the Army when speaking of the engineers and ordnance, says:

> Their duties are connected with the permanent preparation, and defense of the country, and have so little reference to the existing military establishment, that if the Army were reduced to a single regiment, no reduction could safely be made in either of them.

At the time Mr. Calhoun wrote, the Corps of Engineers was engaged exclusively upon fortifications, and it is only since 1824 that their duties have been so materially increased in other directions.

These duties have been enumerated above, and are at this time of such extent as to render it physically impossible, for the present number of officers in the corps to perform them without the aid of civil assistants. The extent of increase of the duties of officers of the Corps of Engineers is shown from the fact, that from 1821 to 1828, the period covering the time that General Macomb was Chief Engineer, the amount of six millions of dollars only, was disbursed by the corps upon the works in its charge. For the four years from 1849 to 1853, seven and a half millions of dollars only, were disbursed on some two hundred and fifty works, while for the period from 1867 to 1875, an average sum of eight and three-quarter millions per year, upon some four hundred and seventy works, has been disbursed by the Corps of Engineers. The labors devolved upon the engineers, upon public works alone, since 1853, have increased over four fold, while the authorized increase of commissioned officers of engineers, over those authorized at that date, has been but thirty officers, some 37 per cent only of the number of officers provided by the act of July 5, 1838 increasing the military establishment, and but a few more than are necesasry to officer the Battalion of Engineers created since that date.

The public interest would be enhanced by an increase of the Corps of Engineers; and it is recommended, that the first lieutenants be increased to thirty, making an addition of four first lieutenants, and the second lieutenants to thirty, making an addition of twenty second lieutenants, in all, twenty-four lieutenants, to be promoted and appointed as now provided by law and regulations.

WHETHER ANY AND WHAT REDUCTION CAN BE MADE IN NUMBERS, OR PAY, OR OTHERWISE, CONSISTENTLY WITH THE PUBLIC SERVICE.

In my judgement no reduction can be made in the number of the corps consistently with the public service; on the contrary, we should have a greater number of subalterns, to take the places of many of the civil assistants we are now forced to employ. From the last returns, this number was some one hundred and thirty-five. The field-officers of the corps, and some of the captains even, are in charge of works or operations of the greatest value to the country, and some of them are overloaded with work. As to the pay and allowances of the officers of engineers, that has previously been stated to be the same as that of the same grades in the cavalry, and when compared to the compensation of engineers in civil life, having corresponding responsibilities, is very much less than they receive.

A comparsion of the grades in the engineers, with the rest of the Army, will show that, relatively, it has no greater amount of rank than it had in 1838, that the proportional increase of field-officers since that date, has not been quite as great as in the remainder of the Army, and that the rapidity of promotion in the corps, has not been as great as in the rest of the Army.

The corps is organized, and has exercised its functions in the interests of a just and reasonable economy, and is ready for any service that may be demanded of it, whether with the troops in the field, or upon the various and extensive duties intrusted to it in time of peace.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. J. D. CAMERON,
Secretary of War.

HISTORY OF THE ENGINEER BATTALION

A paper read before the "ESSAYONS CLUB" of the Corps of Engineers, Dec. 21, 1868,

By THOMAS TURTLE,

First Lieutenant of Engineers.

The first Engineer troops were organized by act of Congress, May 16, 1846, to consist of one company, of ten sergeants, ten corporals, two musicians and seventy-eight privates. The headquarters rendezvous was West Point, N. Y., in command of Capt. Alexander J. Swift, Corps of Engineers. The first enlistment was made May 28, 1846.

The company was officially organized by an order from the Engineer Department August 11, 1846, assigning Capt. Swift to its command, and 2d Lieut. G. W. Smith and Bvt. 2d Lieut. G. B. McClellan to duty with it.

As soon as it was ready for service it was ordered to Mexico, its commanding officer being directed to report with it without delay to Gen. Taylor by an order from the A. G. O., September 12, 1846.

The company was put on board the ship *Clinton*, and sailed from New York September 26, 1846, being, as near as I can judge from the records in my possession, about seventy-five strong. It landed at Brazos Santiago, Tex., October 12, 1846, and proceeded from there to a point opposite Camargo, Mexico, on the Rio Grande, about 100 miles in a right line from Brownsville. Leaving this place it moved to Matamoras, and passed through Victoria to Tampico, acting as pioneers to the army. Capt. Swift was left sick at Matamoras.

The company of Engineer troops belonged to that portion of Gen. Taylor's army which was detached from his command, and attached to that of Gen. Scott. It embarked at Tampico on the 24th of February, 1847, and joined Gen. Scott's army at the rendezvous at Lobos Island—

about 125 miles north of Vera Cruz. Capt. Swift with Lieut. Foster here joined the company, with those men who were left sick at Matamoras. Lieut. Foster was with him.

During the siege of Vera Cruz the company was engaged in superintending the construction of the batteries and trenches, being continually under fire, and after the fall of the city was engaged in a survey of the enemy's works. It then moved forward with the army.

At Cerro Gordo it constructed the batteries against the Mexican lines, and on the morning of the 18th of April it was divided into three portions, one of which was attached to each of the columns of attack. The strongest portion, under Lieut. G. W. Smith, was attached to the centre column, commanded by Gen. Twiggs.

Capt. Swift had been obliged by sickness to leave the company during the siege of Vera Cruz, and died at New Orleans on his way home.

After the battle, the company accompanied the army on the road to Mexico. At Contreras it formed part of the storming party. In the words of Gen. Scott:

"Smith's own brigade under the temporary command of Maj. Dimick, following the movements of Riley and Cadwallader, discovered, opposite and outside the works, a long line of Mexican cavalry drawn up as a support. Dimick having at the head of the brigade the company of sappers and miners under Lieut. Smith, Engineer, who had conducted the march, was ordered by Gen. Smith to form line facing the enemy, and in a charge against a flank, routed the cavalry."

The action of Contreras over, Lieut. Stevens, of the Engineers, was sent to reconnoitre the church of Churubusco, covered by the company of sappers and miners. It formed part of the storming party on this occasion.

Lieutenant Foster was detached with ten men of the company to join the storming party at Molino del Rey. Lieut. Foster was here badly wounded.

At Chapultepec the company was engaged in the construction of batteries. Whenever their work allowed they joined in the fight with their muskets.

As soon as Chapultepec was carried, the troops engaged pressed on to the Garita San Cosmo. The following extract is from the report of Maj. John L. Smith, Corps of Engineers.

"Lieut. Stevens served under the orders of the General-in-Chief during the action of Chapultepec, on the 13th, and afterwards with the division of Gen. Worth in its advance to the San Cosmo suburb. Having moved to the head of the column and perceiving that the enemy's works at the junction of the Chapultepec and San Cosmo roads, were not armed with cannon, and that the enemy's force was not large, he suggested to Col. Garland to sieze the position and occupy it, and on learning his orders did not allow him to advance, he reported to Gen. Worth the result of his observations, and was directed by him to proceed with a message to the General-in-Chief at Chapultepec. He reconoitred the position again and shortly after our troops advanced and occupied the San Cosmo suburb. Soon after this, while reconnoitring a straggling force of the enemy and posting a picket to observe it, he was disabled by a wound in the foot.

" Lieut. G. W. Smith, commanding the sappers, arrived on the ground some time after this, while our troops were in front of the battery at the Garita, the other batteries on the road up to that point having been carried. Being the senior Engineer present, he was ordered to reconoitre in front and ascertain the state of the enemy's forces, and particularly whether it would be necessary to move our heavy artillery forward. He reported his opinion that the advancing of the heavy pieces should be suspended, and that the sappers should advance under the cover of the houses, by openings made in the walls of the continuous houses, and this being approved, he proceeded in the manner proposed, until he reached a third-story house about forty yards from the battery, and was enabled from the roof, to open a fire upon the battery which drove away the enemy's troops who, in their retreat, succeeded in carrying away one of their guns.

" Part of his force then descended to the road to secure the guns, but was anticipated by a body of our troops which entered on the right as the sappers were about entering on the left. The sappers were then moved forward until they reached strong positions on both sides of the rear, capable of affording shelter to our troops, although the enemy occupied in force a large convent, 150 yards in advance, and had batteries in the next cross-street. These facts being reported a brigade was sent to occupy the strong positions referred to, and at 10 P. M. further operations were suspended for the night.

"At 3 o'clock next morning a party of sappers moved to the large convent in advance and found it unoccupied.

" Lieut. McClellan advanced with a party into the Alameda and reported at daylight that no enemy was to be seen. The sappers then moved forward and had reached two squares beyond the Alameda when they were recalled. The company during the day were engaged in street fighting and particularly in breaking into houses with crowbars and axes.

In this service they killed a number, and made prisoners of many suspicious persons.

"Lieut. McClellan had command of the company for a time in the afternoon while Lieut. Smith was searching for powder to blow up houses from which our troops were fired upon contrary to the usages of war. During this time while advancing the company, he reached a strong position, but found himself opposed to a large force of the enemy. He had a conflict with this force which lasted some time, but the advantage afforded by his position enabled him at length to drive it off, after having killed more than twenty of its number."

This practically ended the fighting in Mexico and also the services of the company in this war. It was sent to West Point by way of New Orleans by an order from Capt. R. E. Lee, Corps of Engineers, dated June 6, 1848.

In every battle in which it was engaged in this war, the company received honorable mention in the official reports of the officers to whose command it was attached, as well as in those of the commanding general himself.

A detachment of the company of about twenty-five non-commissioned officers and men, accompanied Stevens' survey of the North Pacific Railroad in 1853, under the command of Lieut. A. J. Donelson, Corps of Engineers.

The company left West Point enroute to Utah on the 31st of March, 1858, under the command of 1st Lieut. J. C. Duane, Corps of Engineers, leaving behind a detachment of one sergeant, four corporals, one musician, nine artificers and ten privates, commanded by Bvt. 2d Lieut. H. M. Robert. The duties of the company in this expedition were those of pioneers to the army sent to the relief of Sydney Johnson, cutting roads, building bridges, &c. It reached Fort Bridger August 1, 1858, and after remaining there eight days resumed the return march to West Point, arriving at the latter post on October 13, after having marched over eleven hundred miles in fifty-six days.

In September previous the detachment that had been left at West Point was ordered to the Pacific coast. The following is an extract from a letter received from Col. Houston, who commanded the detachment:

"The detachment numbering 30 men, officered by myself and Lieut. H. M. Robert, left West Point in September, 1858, for Fort Vancouver. I presume the records of the company will give the names of the non-commissioned officers and men.

"The detachment had been applied for by Gen. Harney, who had been ordered to Oregon in anticipation of extensive Indian difficulties after the disastrous defeat of Col. Steptoe. The Indians, however, had been brought to terms by Col. Wright before the arrival of Gen. Harney, so that there seemed to be no especial need of the Engineer detachment after its arrival. We were, however, at once ordered to the Cascades of the Columbia, with instructions to make a new road over the portage at that point if practicable, and, if not, to repair the old road. No better route than that of the old road could be found and the detachment was employed during the winter of 1858–59 in repairing the road. It rained nearly all the time and I doubt whether more unpleasant service has ever been performed by our Engineer troops during the time of peace.

"In the spring of 1859 an expedition was organized under command of Capt. Henry D. Wallen, 4th Infantry, consisting of two companies of cavalry, one of infantry and the engineer detachment, for the purpose of opening a new and shorter route from the Dalles to Salt Lake, striking the Snake River in the vicinity of Fort Boise.

"The duties of the detachment in addition to the regular guard duty, which it was required to perform in common with the other troops, consisted in crossing the command over streams not fordable; preparing the banks and bottoms of fordable streams; making temporary bridges, and making roads whenever necessary to permit the passage of trains.

"The command left the Dalles on the 4th of June, 1859, and after a march over as hilly a country as one wishes to travel in, arrived at the Des Chutes River on the 12th of the same month. The crossing of this river was the most important work performed by the detachment during the expedition. The stream was eighty yards wide with a very rapid current. The material to be crossed consisted of thirty wagons with their loads, the loads of 300 pack mules and the men of the command.

"After crossing this river the command proceeded on its route. As the country became more and more difficult as we proceeded, it was decided on the 27th of June that the route over which we had passed was impracticable and it was determined to send back all but four wagons with an escort, which was directed to take another route while the main body pushed on to Salt Lake. Ten men of the detachment under command of Lieut. Robert were sent back, and the remainder accompanied the command to Salt Lake, and returned with it by the old emigrant route to the Cascades in the fall of 1859. Nothing of moment occurred especially affecting the detachment. On our arrival at the Cascades we commenced the construction of a bridge on the portage road.

"The detachment under Lieut. Robert on its return, was ordered to open a route from the Columbia River to Puget Sound, and when the difficulties in relation to San Juan Island broke out, it was ordered to the island and employed in fortifying it.

"After the joint occupation of the island by the two governments, the detachment was ordered to the Cascades where it arrived in January, 1860.

"Col. Casey arrived at the same time and relieved me. I cannot give you the dates of these movements but I suppose they can be found in the company records."

After its arrival at the Cascades the detachment built a bridge between the upper and lower Cascades, which required three months to construct, after which it cut a road to Fort Steilacoom on Puget Sound. While at Fort Steilacoom the detachment was drilled in the preparation of siege material.

In the spring of 1861 the detachment was ordered to San Francisco, where it remained about two months, part of the time in command of an artillery officer, Lieut. A. G. Robinson, now Bvt. Major and Assistant Quartermaster.

The detachment left the Pacific coast in June, 1861, and proceeded to West Point, where it remained a short time. It was then ordered to Washington and was engaged on the construction of the defenses and afterward in the instruction of the 15th New York Volunteer Engineers in the preparation of siege material. It was later joined by the main portion of the company, which had just returned from Fort Pickens.

The main portion of the company after its return from Utah, remained at West Point until January 20, 1861, when it was ordered to Washington to guard the public buildings, stores and arsenals during the excitement preceding the rebellion. It formed part of the escort of President Lincoln at his first inauguration. It remained at Washington till April 3, when it left at 6 A. M. for Fort Hamilton, N. Y., arriving at Fort Lafayette at 6 P. M. on the same day.

On the afternoon of the 7th the company embarked on the steamer *Atlantic*, which sailed next morning under sealed orders. The *Atlantic* arrived at Santa Rosa Island, April 16. The company disembarked at 11 P. M., and reached Fort Pickens between 12 and 3 next morning.

While at Fort Pickens, the company was engaged in putting the works in a state of defense, building traverses, bomb proofs and exterior batteries. It left Fort Pickens September 17, 1861, reaching West Point on the 30th, where it remained during the month of October and left on the 31st for Washington.

By Act of Congress of August 6, 1861, the U. S. Engineer troops were increased by the addition of three companies of 150 enlisted men each. One company of topographical engineers was allowed by the same act. This latter company was not organized till after the war and the men enlisted for it (only some half dozen) were sent to the engineer companies.

Of the additional companies of engineers, one (Company C) was organized at Boston, and one (Company B) at Portland. These joined the old company (A), at Washington in the fall of 1861. The third additional company (Company D), was organized by transfer from Companies A, B and C, while the Army of the Potomac lay at Harrisons Landing (July 4, 1862).

During the winter of 1861–62 the engineer troops were engaged in the construction of works in the vicinity of Washington and in building a ponton bridge at Harpers Ferry.

From this time to the close of the war the engineer troops were on duty with the Army of the Potomac.

At the siege of Yorktown:

"The Battalion was engaged on the trenches and communications, from the beginning to the end of operations. It furnished superintending and instructing details for parts of the entire line. The Battalion also assisted in making roads, and laid several bridges of pontons, three of the most important of which were composed of batteaux and crossed the north branch of Wormley Creek. The troops of the line at this early period of the war had received no practical instruction in making batteries and throwing up breastworks. The Battalion was drawn upon heavily in consequence, to furnish men, who always performed the duty of laying out the works, and imparting instruction to the troops of the line. Almost the entire line of trenches was in charge of Duane and his officers and men of the Battalion."*

At Fair Oaks the Battalion was under arms during the entire night at New Bridge on the Chickahominy, awaiting orders to throw a bridge; and next morning was engaged in building one bridge and part of another, and in constructing the roads leading to the same. During the construction of these bridges the rebel sharpshooters had possession of the opposite bank of the river.

A portion of the Battalion at the battle of Mechanicsville was ordered to New Bridge for the purpose of tearing up the bridge at that point as soon as the army had crossed. The Battalion was subsequently ordered to Gaines' Mills, where it threw up intrenchments on the right of Gaines' house. Portions of the Battalion were stationed at the different bridges to destroy them as soon as the army should finish crossing. They were under arms all night, and destroyed the bridges just after daylight on June 28, the enemy appearing on the opposite bank before the work of demolition was fairly over. The roads to the rear were also put in proper condition for use, a portion of them being impassable. After the battle of Gaines' Mills the Battalion was ordered to White Oak Swamp in advance of the army to repair the roads and crossing, which were impassable, and to again render them impassable after the army had passed. At Malvern Hill the Engineer Battalion was posted on the edge of a piece of woods to act as infantry. It received orders to slash this piece of timber in such a manner that by cutting a few trees the whole would fall. In this it was assisted by the 4th Maine Volunteers. After the army had left Harrisons Landing the Engineer Battalion, assisted by the Volunteer Engineers, built the bridge near the mouth of the Chickahominy. This bridge was about 2,000 feet in length.

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*Letter of Bvt. Brig. Gen. C. B. Reece, Major, U. S. Corps of Engineers.

The night before the battle of Antietam the Battalion rendered three of the fords of Antietam Creek passable for artillery, by cutting down the banks and paving the bottom with large stones where it was too soft. During the battle the Battalion guarded and kept open these fords. The night after the battle the Battalion, at the request of its commander, was ordered to report to Gen. Porter to act as infantry and in that capacity supported Randall's battery of the First Artillery in the advance to Shephardstown. After the arrival of the army at Harpers Ferry it built one bridge over the Potomac and another over the Shenandoah and was busily engaged on the fortifications during the month it remained there. Assisted by the Volunteer Engineers it built a bridge over the Potomac at Berlin.

The night before the battle of Fredericksburg the Battalion threw a bridge below the city by successive boats, without an infantry support on the opposite shore, at what was afterwards known as "Franklins Crossing." During the winter the Battalion was engaged upon the defenses of Potomac Creek, Brooks Station and Acquia Creek.

At Chancellorsville the Battalion threw a bridge at Franklins Crossing. The boats were massed the morning before, one mile from the river, in a pine forest. At night they were dismounted and carried by infantry to the crossing, without the enemy being aware of the movement until the boats were actually in the water. The Engineer Battalion and the 15th

N. Y. Volunteer Engineers ferried the infantry across in the face of musketry fire from the breastworks on the opposite bank. The Engineer Battalion afterwards built the first bridge, 390 feet in length, in an hour and ten minutes, and had from this till the close of the battle two bridges in charge, moving them during the battle from the Franklin Crossing to Fredericksburg, where they were laid and communication at that point kept up. After the battle there was not time to dismantle them in the usual manner, and the method by conversion had to be resorted to. The material was removed noiselessly, the men taking off their shoes. The last plank had scarcely been removed when the enemy appeared on the opposite bank.

Capt. Cross, Corps of Engineers, commanding Company B was killed on June 5, while crossing the Rappahannock. It was repeatedly attempted to throw the bridge without dislodging the enemy's skirmishers on the opposite bank. It was found impossible. Forty-five ponton boats were then launched and filled with soldiers, the troops of the Engineer Battalion assisted by the 50th N. Y. Volunteer Engineers taking charge of the boats. Cross was killed in one of these boats. The bridge was built on the afternoon of that day.

"On the transfer of the army to Pennsylvania, a ponton bridge was thrown at the mouth of Ocoquan and one at Union Mills, twenty miles higher up. When they arrived at Alexandria the ponton boats were towed to Washington and thence up the canal to Edwards Ferry where a bridge was thrown for the army. During the engagement at Gettysburg, excepting a few men who were detached, the whole Battalion was kept at Westminister to guard the town and to barricade the streets and the roads leading to town against Stewart's Cavalry. On the 6th of July, 1863, a wooden crib bridge, about 150 feet long, was constructed across Antietam Creek near Jones Crossroads."

On the advance from Centreville after the retreat from the Rappahannock, the Battalion repaired the pike from stone bridge on Bull Run to New Baltimore, removing the old bridges and constructing new ones where necessity required. At the attack on Rappahannock Station it was sent to build a bridge at Kelly's Ford. A bridge was built at this point November 7, under fire. At Jacobs Ford two companies of the Battalion built the bridge, the other two built the bridge at Germania Ford. The Battalion guarded these two bridges during the Mine Run campaign.

The Engineer Battalion was engaged, under the direction of Gen. Duane, as Chief Engineer of the Army of the Potomac, at the Wilderness, Spottsylvania, River Po, North Anna, Cold Harbor and siege of

Petersburg till the surrender of Lee. At the battle of the Wilderness it acted as infantry, being placed, together with the 50th N. Y. Engineers in line on the right of the 5th Corps, crossing the turnpike to check the rebel advance. They held their position until the 6th Corps reformed and took up a new line. At Spottsylvania it was engaged in the construction of bridges across the Po and also in the construction of batteries along the line, the greater part of the time under fire. At Cold Harbor A Company was with the 2d Corps, B Company with the 6th and the other two with the 9th and 18th Corps engaged in constructing batteries and advancing our lines during five days and nights, mostly under fire. A portion of the Battalion attached to the 2d Corps was engaged in running a mine to blow up the enemy's battery occupying the crest overlooking Gaines' Mill. The army moved before the mine was completed. On the night preceding the army's departure from Cold Harbor, the Battalion fortified a short defensive line running through the town, to be held by two corps during the flank march of the army.

It seems that the extent and value of the services rendered by the Battalion in the building of the ponton bridge across the James, over which Grant's army passed, was overlooked or ignored in the reports of that operation. "When the Battalion reached the river, Gen. Weitzel was there with several companies of the 1st U. S. Volunteer Engineers, and nothing was done towards a commencement of a bridge. The boats with their material were scattered in confusion over the low marshy ground, stretched along the shore, and the officer of volunteers could not make his men go into the mud and slime to bring the boats ashore. Gen. Weitzel expressed his gratification to Capt. Mendell (commanding the Battalion) in warm terms at its arrival. At the word of command to build the bridge, the detachments, non-commissioned officers leading, jumped into the mud and water almost to their necks, and by commendable but unrewarded zeal and energy succeeded in one hour in building a bridge abutment 150 feet long, that reached the water proper—it was then that the volunteer work began. The Battalion was afterwards transferred to the opposite shore."

At Petersburg the duties of the Battalion were of a most extended character. From the moment our army appeared before the town to the evacuation every officer and man was engaged upon the defenses superintending the construction and doing the finer work—the front being more especially favored by them. In addition to the small mine at Fort Steadman, several shafts were dug at Fort Sedgwick, familiarly known as Fort Hell. These shafts were sunk in the outer ditch and were connected with each other and extended to the front.

At 1st Hatchers Run the Battalion held a portion of our lines near the Peebles House. At the 2d Hatchers Run it was sent by Gen. Humphreys to the support of Gen. Miles and placed in line on his right.

It was at all times held in readiness to act as infantry and in every case of emergency was used to strengthen some weak point of the long line held by the army, and "ever evinced that ready spirit for duty in this new sphere that characterized it in its own." The construction, repair and strengthening of our line from the Appomattox to Hatchers Run were under its immediate care.

During the last campaign the Battalion moved with Headquarters and was present at Lee's surrender, the officers of the command performing staff duty at Gen. Meade's Headquarters.

After the surrender of Lee the Engineer Battalion took charge of the Engineer trains of the army, and of their shipment to Willets Point. Companies A, B and D arrived at Willets Point in June, 1865, and Company C in December. Company A immediately after its arrival at Willets Point was ordered to West Point, where it remained until September, 1867, when it was again ordered to Willets Point. Company D had been previously sent to San Francisco (August 31).

By Act of Congress approved July 28, 1866, the "Battalion of Engineers," received its present organization, viz, five companies of one hundred and fifty enlisted men each, one sergeant major and one quartermaster sergeant. Before this it had no Battalion formation properly speaking, being simply an aggregation of companies, the senior captain commanding. In orders it was designated "Battalion of Engineers." Captain Mendell when commanding it, in the the fall of 1863, appointed an Adjutant.

The fifth company (E) was recruited at Detroit in the fall of 1865, and ordered to Jefferson Barracks, St. Louis, Mo., where it still remains. (December, 1868.)

COMPANY A, CORPS OF ENGINEERS, U. S. A., *in the* MEXICAN WAR, 1846-'48,

By GUSTAVUS W. SMITH,

Formerly Lieutenant of Engineers, and Brevet Captain, U. S. Army.

CHAPTER 1.

ENLISTMENT—INSTRUCTION—DETENTION ON THE RIO GRANDE—MARCH TO VICTORIA AND TAMPICO LANDING AT VERA CRUZ—DEATH OF CAPTAIN SWIFT

Previous to the war with Mexico there existed among the people of the United States a strong prejudice against maintaining even a small regular army in time of peace. Active opposition to a permanent, regular military establishment extended to the West Point Academy, in which cadets were trained and qualified to become commissioned officers of the army. That Academy was then a component part of the Military Engineer Corps. For years the chief of the Corps had, in vain, urged upon Congress, the necessity for having, at least one company of enlisted engineer soldiers as a part of the regular army.

In the meantime he had, however, succeeded in persuading the Government at Washington to send—by permission of the Government of France—a selected Captain of the U. S. Engineer Corps to the French School of engineer officers at Metz; for the purpose of having in the U. S. Army, an officer qualified to instruct and command a company of engineer soldiers in case Congress could be induced to authorize the enlistment of such a company.

Captain Alexander J. Swift was the officer selected to be sent to Metz. On his return to the United States, he was assigned to temporary duty at West Point awaiting the long delayed passage of an act authorizing the enlistment of a company of U. S. Engineer soldiers.

That act was passed soon after the commencement of hostilities with Mexico. It provided for the enlistment of an engineer company of 100 men, in the regular army. The company to be composed of 10 segeants, 10 corporals, 39 artificers, 39 second class privates, and 2 musicians; all with higher pay than that of enlisted men in the line of the army.

Captain Swift was assigned to the command; and, at his request, I was ordered to report to him as next officer in rank to himself. At my suggestion, Brevet Second Lieutenant George B. McClellan, who had just been graduated from the Military Academy, was assigned as junior officer of the company.

At that time I had been an officer of engineers for four years; my rank was that of second lieutenant. All the first lieutenants, and some of the second lieutenants, of that corps, were then in sole charge of the construction of seperate fortifications, or were engaged in other important duties. Captain Swift was not disposed to apply for the assignment of any of those officers to be subalterns under him in a company of soldiers. * * *

In the beginning I was charged with the instruction of the company as an infantry command, whilst the Captain took control of the recruiting, the collection of engineer implements—including an India Rubber Ponton Bridge—and he privately instructed McClellan and myself, at his own house, in the rudiments of practical military engineering which he had acquired at Metz. In the meantime we taught him, at the same place, the manual of arms and Infantry tactics which had been introduced into the army after he was graduated at the Military Academy. In practical engineer drills the Captain was always in control. * * *

On the 26th of September, 1846, we sailed from New York, 71 rank and file, for Brazos Santiago, under orders to report to General Taylor, commanding the U. S. Army in Mexico. We landed at Brazos on the 12th of October, remained at that point for several days, proceeded thence to the mouth of the Rio Grande and arrived at Camargo on the 2d of November. There the company was delayed for several weeks because transportation for the engineer train to the headquarters of the Army at Monterey, was not then available.

The Company left Carmargo for Brazos, on the 29th of November, under orders to proceed to Tampico by sea, but was ordered to return to Matamoros with a portion of its tools, and march, via Victoria, to Tampico—the bulk of its train to be transported to the latter place by water.

Whilst detained at Camargo instruction in the school of the engineer soldier was kept up, and infantry drills were constantly practiced. During that time several thousand troops were in camp near Camargo, and the men of the engineer company learned that they were, by the line of the army, styled: "the pick and shovel brigade." Their officers advised them not to care for this epithet but, "take it easy, continue to endeavor to become *model* infantry, and engraft on that a fair knowledge of the duties of the engineer soldier." They were assured that "for heavy work," details would have to be made from the line of the army; and these details would, for the time, constitute the real "pick and shovel brigade" under the control of engineer officers, assisted by trained engineer soldiers. When the time came for close fighting the engineer company would be at the front.

The troops stationed on the Rio Grande during the fall of 1846, suffered greatly from Mexican diarrhœa, fevers and other diseases. Several men of the engineer company died, and Captain Swift and twenty of the men were left in hospital at Matamoros, when the company finally left the latter place.

Before giving an account of our first march in the enemy's country, it may be well to state here, that with two exceptions, the enlisted men of the engineer company were native born, and all but four of them were raw recruits. Each of these four had served, with credit, during one or more terms of enlistment in the regular army. Three of them were promptly made sergeants, and the fourth was a musician (bugler.) * * *

THE MARCH FROM MATAMOROS TO VICTORIA AND TAMPICO.

By special orders from General Taylor, brought by Major George A. McCall to Captain Swift, the latter was charged with the duty of repairing the road from Matamoros to Victoria, and making it practicable for artillery and the baggage train; and to do this, if possible, so that the whole command might make its prescribed daily marches and arrive at Victoria on a named day. Captain Swift was authorized to call upon the commander of the forces, on this march, for such assistance as might be needed to perform the work; and was directed to do no more to the road than was barely sufficient to enable the trains to pass over it. It was not expected that we would ever have occasion to pass through that region again; and it was not proposed to make a permanent road for the benefit of Mexicans.

Captain Swift being sick in hospital, the foregoing instructions were given to me, as Commander of the company, by Major McCall, who, in the capacity of Adjutant-General of the forces under General Patterson, accompanied him on this march.

Under orders from General Taylor, the company of engineers, reduced to two officers and forty-five enlisted men for service, marched from Matamoros on the 21st of December, 1846, with a column of volunteers under General Patterson, to join General Taylor's army at Victoria. We arrived at the latter place on the 4th of January, 1847. A great deal of work had been done by details of volunteers and the engineer company in making the road practicable for artillery and baggage wagons. Without dwelling upon daily operations, the following statement of the manner in which we made our way across a difficult stream may be of interest.

About noon one day I was informed by Major McCall, who had ridden ahead of the working party, that there was an exceedingly difficult "river crossing" about one mile in front, and that he feared we would be detained there for, perhaps, two days. I galloped forward to the place designated. It looked ugly. The banks of the stream were something more than 100 feet high and quite steep. Guiding my horse down to the water's edge, I crossed the river which was from two to three feet deep, and about one hundred yards wide. The bottom was fair enough, until within a few yards of the opposite shore, where it was soft mud. Getting through this with some difficulty I rode to the top of the bank on the far side.

To make an ordinary practicable road across that stream would require two or three day's work of several hundred men. It seemed a clear case for the free use of drag-ropes to let the wagons down into the stream on the near side, and haul them up the opposite bank.

It was plain to me that with a working party of two hundred men —which was the greatest number we could supply with tools—a straight steep ramp could be cut on both banks in six or eight hours hard work. The greatest difficulty would be encountered in getting out of the stream on the far side.

Returning quickly to where I had left Major McCall, I asked him to give me a working party of about 800 men, told him I would find use for that number and that in my opinion, with that force, the wagon train could be put across the stream before dark. The commanding General thought my requisition for the working detail was extravagant, as we scarcely had tools enough for a quarter of that number of men. But the detail was ordered, as called for, to report to me. In the meantime the engineer company and its train was taken to the crossing, and the character of the work to be done there was explained to the men.

Leaving Lieutenant McClellan with a portion of the company to take charge of the near bank, directing him to halt there about 300 of the working party and send about 500 to me on the opposite bank, I crossed the stream with the rest of the company and explained to them the work to be done on that side, particularly the means to be used in getting out of the river. On each side of the stream the working party was divided into three "reliefs," or relays—with one hundred men or more held in reserve, to meet contingencies.

The working party arrived in good season, tools were promptly distributed to the first "relief" on each side of the river, and the men were told that, if they would work as at a "corn-shucking-match," or as if the "house was on fire," they would be let off in an hour, or less, depending on the rapidity and effectiveness of their work. It was to be a race against time. I wanted all the work there was in them, and wanted it inside of an hour.

Before the hour was up the "first relief" on each side of the river, was ordered to stop work, drop their tools, get out of the road and take to the bushes. The "second relief" was immediately marched into the vacated places, seized the tools, and worked like the first—and on the same conditions. So with the "third relief;" and, inside of three hours from the time the work began, the engineer wagons were crossing the river. They soon moved on, leaving the rest of the forces to follow at their leisure.

The volunteer officers afterwards complained to me that the "wild work" on the banks of that river, had "scattered" their men so badly, it was several days before they could be again got into their proper places.

This case was an exception—a frolic. The usual daily work on the road was more regular and continuous, without disorder.

It may perhaps not be out of place here to mention, that about the time I sent the "first relief" into the bushes, and set the "second relief" to work under the directions of men of the engineer company, the commander of the forces, with his staff, arrived on the bank where McClellan was in charge, and asked for me. He was told that I was on the opposite bank. Just at that time the confusion and wild yells of the "first relief" and the loud cheers of the "second relief" when told that they, too, would be let off inside of an hour, provided they would work as if engaged in a "corn-shucking-match," astounded the general, and had to him the appearance of disorder, perhaps mutiny.

On asking Lieutenant McClellan what it meant, the latter replied: "It is all right; Lieutenant Smith has the larger portion of the engineer company with him on that bank; and I can see him, and men of the company near him in the road, all of whom seem to be quietly giving instructions to the new working party."

After starting the "second relief" to digging in the road, I had gone to the brow of the bank overlooking the work which was being done, mostly by my own men in the river, where the road was to leave it. The engineer sergeant in charge of that work informed me that he was then in immediate need of about twenty additional men. The reserve working force was not far from me. I called out for a sergeant and twenty men, without arms or accoutrements, to come to me. Pointing to the river, just under the place at which I was standing, I directed the sergeant of this reserve party to take his men down at once and report to the engineer sergeant in charge there. The bank was precipitous. The sergeant of the reserve working party said that he would take his men back about one hundred yards, and go down by the road on which the "second relief" was working. I demurred, and told him again, to take his men straight to where they were needed. He still hesitated. I pushed him over the brow of the bank, and he went headlong into the river. I then ordered his men to follow him. They did it with a cheer and regular "Comanche-whoop"—sliding down the slope, which was too steep to stand on.

This scene, too, was witnessed from across the river bv the General of the forces and his staff. I did not know they were there; but if I had, it would have made no difference; I was in charge of the working party, and in haste to finish that *special job.*

On our arrival at Victoria, the company was relieved from duty under General Patterson, and I was directed to report to the headquarters of General Taylor. On the 12th of January the company was ordered to report to General Twiggs. With two companies of the line to furnish additional details for labor when required I was charged with the duty of making the road between Victoria and Tampico practicable for wagons. These three companies left Victoria on the 13th.

The following extracts from my official report of the operations of the Engineer Company for the month of January, 1847, illustrate, in part, the difficulties met with.

"The first day, (out from Victoria,) we had three bad boggy brooks to cross; besides a great deal of cutting to do with axes in order to open the road; and many bad ravines and gullies to render passable. To make a bridge, across a boggy stream, with no other material than the short, knotty, hard and crooked chapparal bush, was no easy matter. The first day's march was about ten miles—we encamped about sunset after a very hard day's work."

In order to shorten the route and save the forces one day's march, we were, for several days, working on a mule path "cut-off" from the main road.

"January 14th. The mule path was infamous. No wagon had ever traveled that road—the rancheros have a tradition of a bull cart that, it is said, once passed that way. I believe, however, that the story is not credited. We worked from dawn of day until dark and encamped about six miles from where we started in the morning and about the same distance from the camp we wished to reach that day."

"January 15th. Another day's tremendous hard work."

"January 16th. We had again a very severe day's work."

"January 17th. Road improved very decidedly, but still a good deal to do. We managed, by getting a little ahead with our repairs after the army encamped for the night, to get along without seriously delaying the column."

We arrived at Tampico on the 23d. The distance from Victoria to Tampico is 120 miles; whole distance from Matamoros to Tampico, by way of Victoria, is 354 miles.

Although the service was arduous, the men came through it in good health, and were all the better soldiers for the practical schooling acquired in that 350 miles of road making. After this experience, ordinary marches and drills were to them, very light matters.

TAMPICO TO VERA CRUZ.

From Tampico we sailed for Lobos Island and Vera Cruz, on a small schooner, the Captain of which was a brave little Frenchman, who was not acquainted with the Mexican Gulf coast, and was not provided with accurate instruments for taking observations. Late one afternoon the clouds rolled away, and we distinctly saw the snow-clad peak of Orizaba. This was the first intimation to us that we were "somewhere," near Vera Cruz. In a very short time we saw opposite to us a large fleet of vessels at anchor.

We were south of Vera Cruz and were passing Anton Lizardo, the place to which we were bound. But a reef was between us and the anchorage where the fleet was quietly lying. The Captain of the schooner said he could cross the reef. Taking his place in the rigging from where he could better observe the breakers and the currents, the schooner tacked here and there, rapidly and repeatedly, under the orders of the little Frenchman; and we were soon clear of the reef and breakers. It was now nearly dark. In a few moments after reaching the anchorage ground, we glided up a gentle slope, without perceptible shock; and the bow of the vessel was almost entirely out of water.

In less than twenty minutes thereafter a boat from one of our men-of-war pulled alongside; and when the officer in charge learned who we were, he said he would report at once to the naval commander; and had no doubt that the company with its effects would have to be landed on an adjacent island, while the schooner was being lightened and hauled off into deep water.

He said the movements of the little schooner, through the heavy surf, across the dangerous reef, had been watched from the naval vessels with intense anxiety, and expectation that we would be wrecked and all hands lost. This feeling was changed to admiration when it was seen that the schooner was being very skillfully handled in the difficult channel; and all rejoiced when they saw the unknown little craft safely in smooth water; but were surprised, immediately after, to see her put on a course that would inevitably run her aground.

We found that Captain Swift with the convalescents from Matamoros on another vessel, had arrived before us. In the meantime Lieutenant J. G. Foster, of the Engineer Corps, had been assigned to duty with the Company. He was with Captain Swift. I at once reported to the latter, and he resumed command of the Company; but the men remained on separate vessels.

Captain Swift was still very sick; to all appearance more feeble than when we left him at Matamoros. All the men he brought with him were convalescent. In a few days after our arrival at Anton Lizardo, an order was issued by General Scott for the transports to move up next morning, towards Vera Cruz, with a view to landing the army on the main shore, opposite the Island of Sacrificios, two or three miles south of the city. On the morning of the day we were to make the landing the whole company was transferred to another vessel; and all were again together. * * *

The next afternoon, the Captain, standing by the gangway, directed the embarkation of about 20 men in the smaller of the two surf boats in which the company was to land. Just as that boat was ready to pull away to make room for the larger boat, I said to him: "I suppose I am to go with this detachment of the Company; and if so I must get aboard now." He replied "No. I wish you to go in the larger boat with me." To which I said: "All right," and added: "McClellan goes with the detachment?" The Captain said, "Yes."

When the larger boat for the rest of the Company came alongside I relieved the Captain at the gangway and superintended the embarkation of the men in that boat. The Captain was lowered over the side of the vessel in a chair; and I, when all else was ready to pull off, scrambled down into the closely packed boat, and took my place in the bow.

Each boat was rowed by sailors from the fleet under the direction of a naval officer.

We had reason for anxiety in regard to the resistance we might meet with from Mexican batteries that could easily have been sheltered behind the sand hills immediately overlooking the open beach on which the landing was to be made. A single cannon-shot striking one of the closely packed surf-boats would probably have sent it, and all on board, to the bottom. The anxiety of the soldiers was to get ashore before such a fate should befall them. They cared very little for anything that might happen after they were on land; but wished to escape the danger of having the boats sunk under them by Mexican batteries.

When we were within five or six hundred yards of the beach all were startled by the whistling of shells and cannon balls close about our heads. This fire was soon understood to come from our Naval gunboats, and aimed at small parties of Mexican lookouts on shore. No resistance was made to the landing of Worth's division. * * *

That night the company slept among the sand hills a few hundred yards from the shore, undisturbed, except by a flurry of firing which occurred about 10 P. M., between a Mexican detachment and the

Light battalion of Worth's division. This firing continued for a few minutes, and then all was quiet for the rest of the night.

About sunrise next morning, the company moved several hundred yards, into its position on the sand hills, on the right of Worth's division in the line of investment, facing Vera Cruz which was about two miles distant.

The Captain showed wonderful increase of vitality after he reached the shore. He conducted the company to its assigned place in the line of investment without much apparent difficulty in walking through the sand.

But three hours exposure to the hot sun was more than he could bear; his strength was gone. He lost consciousness and was, by my order, carried to the beach on an improvised litter. The sergeant of the party was instructed to report to the naval officer in charge of the surf boats, and in my name, request that Captain Swift be taken as soon as practicable, to the steamer which was the headquarters of General Scott. That request was promptly complied with; but the Captain's vitality was exhausted. He was sent to the United States on the first steamer that left Vera Cruz after the landing was effected, and died in New Orleans within twenty-four hours after his arrival at that place.

Thus, the army and the country lost the services of one of the best officers of the U. S. Corps of Military Engineers; and the engineer company lost their trained Captain.

CHAPTER II.

ENGAGED IN OPERATIONS AGAINST VERA CRUZ.

Within a short time after Captain Swift was taken to the beach, I received an order, from General Worth, directing me to withdraw the engineer company from the line of investment and report to General Patterson. The latter instructed me to locate and open a road through the chapparal to the old Malibran ruins. This was accomplished by the middle of the afternoon. General Pillow, who was to occupy a position beyond Malibran, requested me to take charge of a working party of his troops and, with the engineer company, locate and open a road along his line to the bare sand hills on his left. In this work we were somewhat disturbed by the fire of Mexican detachments.

On the 11th, the work of locating and opening the road along the line of investment was continued, the working party being still a good deal annoyed by both infantry and artillery fire. At 1 P. M., I reported to General Patterson that the road was opened, through the chapparal, to the bare sand hills. He ordered me to report, with the engineer company, to General Worth; and the latter directed me to report to the General Headquarters.

On the same day I was ordered by Colonel Totten, Chief Engineer, to find and cut off the underground-aqueduct which conveyed water into Vera Cruz. That business was effectually accomplished by the engineer company on the 13th.*

From that time, until the commencement of work upon the batteries and trenches, the engineer company and its officers were engaged in reconnoitering the ground between the picket line of our army and the fortifications of the city. My reports were made each night to the Chief Engineer. The night of the 15th, he pointed out to me, on a map of the city and its fortifications, the general location in which it was desired to place the army gun battery, on the southern prolongation of the principal street of the city, and within about six hundred yards of its fortifications. He directed me, with the engineer company, to closely examine that ground. I was informed by him, at the same time, that Captain R. E. Lee, of the engineer corps, had discovered a favorable position for a battery, of six heavy naval guns, on the point of a commanding sand ridge, about nine hundred yards from the western front of the city; but no final decision would be made in regard to the naval battery until the army battery could be definitely located. He said General Scott was getting impatient at the delay; and I was directed to find, as soon as possible, a position that would satisfy the conditions prescribed, by the Chief Engineer, for an army battery.

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*In illustration of the character of the work done during the first two or three days after the landing, the following quotations from General Scott's official report are not irrelevant. He says:

"The environs of the city outside of the fire of its guns, and those of the castle, are broken into innumerable hills of loose sand, from twenty to two hundred and fifty feet in height, with almost impassable forests of chapparal between. In extending the line of investment around the city the troops, for three days have performed the heaviest labors in getting over the hills and cutting through the intervening forests." (Ex. Doc. No. 1, p. 216.)

I explained those conditions to McClellan and to Foster; and informed them that I would assign one-third of the company to each of them as an escort—take one-third myself—and we would all three start, at daylight next morning, in search of a location for the required battery. It was necessary that we should be extremely careful not to get to fighting each other in the dense chapparal.

We found a location that complied with the conditions. In reporting this fact to the Chief Engineer, I added, "The communication with the battery will be very difficult—will require a great deal of work—and will be dangerous." He ordered me to take the engineer company to the selected ground, next morning, and lay out the battery; and said he would direct Lieutenant G. T. Beauregard, who had supervised the construction of the field fortifications at Tampico, to assist in the work.

At 2 P. M., that day the battery and magazine had been traced out, all necessary profiles carefully adjusted; and, the whole completed, ready to commence throwing up the works. We had not been discovered by the Mexicans—though we could plainly see their sentinels on the walls; and occasionally hear words of command. After allowing the company to rest for a couple of hours we started to return to camp.

In going forward we had the Mexicans before us; and by exercising great care, at certain places, could avoid being seen. When our backs were turned to Vera Cruz I felt confident that we would soon be was well understood that the troops having had most to do in the attack were selected to take a prominent part in the proceedings."

We all felt that, if our distinguished Captain had been with us, we would have been called on to take part in those ceremonies.

The Chief Engineer, Colonel Joseph G. Totten, in his report of operations against Vera Cruz, says:

"The obligation lies upon me also to speak of the highly meritorious deportment and valuable services of the Sappers and Miners, [engineer company] attached to the expedition. Strenuous as were their exertions, their number proved to be too few, in comparison with our need of such aid. Had their number been four-fold greater, there is no doubt the labors of the army would have been materially lessened and the result expedited." (Ex.Doc.No. 1,p. 245.)

of the 12th, General Scott consented that the engineer company should, if possible, move with the General Headquarters, which left at 4 P. M., that day.

I then applied direct to the Chief Quartermaster for transportation. He told me that it was impossible to let me have any teams at that time—all the good teams had been taken by the army, General Worth was getting the last.

A positive order from headquarters, was then procured by the Adjutant of engineers, requiring the Quartermaster's Department to furnish transportation for the engineer train, etc. The teams, such as they were, came into our camp about dark on the 12th. That night the wagons were loaded; and we started half an hour before daylight on the 13th.

The mules were wild, the teamsters could not speak English, some of them had never harnessed an animal; and it was soon apparent that the men of the company would have to put their muskets in the wagons and give their undivided attention to the mules. At 2 P. M., after struggling through the deep sand, west of the city, we struck the firm beach, and could make better progress, for about three miles, to Vergara, where the road leaves the coast, and again passes through deep sand.

In the meantime one team had become broken down and useless before we got beyond the city. In order to procure another I had to take some of my own men into the mule pen. Three Mexicans were given me to lasso the mules, and five men were required to put them in harness—seasick, wild, little animals. One teamster deserted; one had his hand, and another had his leg broken; and a number of mules in different teams were crippled.

At Vergara, half the load of each wagon was thrown out, before we entered upon steep ridges and deep sand immediately after leaving the beach. All the men were engaged in helping along the half loaded wagons. That night we slept in the sand ridges.

On the 14th, we reached Santa Fé, eight miles from Vera Cruz, threw out the half loads, and returned to Vergara. Before we again reached the beach, the men had actually to roll the empty wagons up every hill, the mules not being able to drag them. By 10 P. M., we were again at Santa Fé, having killed three mules, and the men being worked nearly to death. Fortunately for us, several good mules that had escaped from preceding army trains, came out of the a quarry hole, I found myself sprawling on a dead Mexican soldier—his glazed eyes wide open, within a few inches of mine. * * *

Before I could regain my feet streams of men were rushing past me in the darkness; and I heard and recognised, the voice of Lieutenant Peter V. Hagner, of the Ordnance, calling in no measured tone or language, upon these stampeded men to stop. * * *

When something like order was restored on the hillside I learned from Lieutenant Hagner that he had been detailed to take one of our heavy guns up the hill to the battery. A regiment of Volunteers had been placed at his disposal to man the drag-ropes. Their arms had been left at the foot of the hill. On finding his way blocked by trees, Hagner had sent to procure axes from the engineer train; and in the meantime the regiment at the drag-ropes had been permitted to lie down. Of course they went to sleep. Suddenly awakened by a false alarm that the Mexicans were upon them, they rushed down the hill to get their arms. Hagner soon procured the required axes and the gun was delivered at the battery in good time.

At daylight I was again at the battery. A slight epaulment had been finished for three pieces of artillery, the platforms were laid, and the guns in position. I was then instructed by Captain Lee, to send ten men to report to him for special service; to order Lieutenant Foster with eight additional men, to report to him [Lee] for the purpose of opening a road for the light artillery around the foot of the heights; and I was ordered, with the rest of the company, to report to Colonel Harney, who was then in command of Persifor Smith's brigade, of Twiggs' division.

I was instructed to accompany that brigade when it moved forward to attack the enemy in position on a hill immediately in front of, and higher than that on which our battery had been constructed. The Mexicans were in strong force on the higher hill.

From our lower position we could not clearly see their lines nor determine how they were fortified. The hill they occupied was flat on top and their lines were set back from the crest of the precipitous slope which faced us. The storming brigade was ordered to halt and reform just before reaching the top of the higher hill. At this point they were below the plane of the enemy's fire, and were when lying down, perfectly protected. In this position they were ordered to rest, until the order should be given to rise, charge and carry the enemy's works by open assault.

When the line was thus formed, I requested Colonel Harney not to give the order to charge until I could go on the plateau, get a clear view of the enemy's works, and report their character. I soon informed him that their main line was not more than forty or fifty yards from where our men were then lying, that the fortifications were very incomplete, offered no effective obstacle, and we could dash over the works without a halt. I then ordered my men to drop their tools and use their muskets.

Whilst I was making this report to Colonel Harney, our attention was drawn to quite a sharp fire that the Mexicans had suddenly opened from a point close to the left flank and in the prolongation of our line. I told him I was certain there were no fortifications in that position; and I had seen no troops there. The fire increased from that direction, and Colonel Harney ordered me to proceed rapidly with my men to the left of our line, direct two companies on that flank to wheel at once, to the left; and when he gave the order to charge, these two companies and the engineers would move to the left against the force that was firing upon us from that side.

These dispositions on our left were made in a very few moments, and the order to charge was given immediately thereafter. The brigade sprang up, dashed over the short intervening space, and were almost instantly inside of the Mexican incomplete works.

After a short, but bloody, hand to hand struggle, in which bayonets, swords, pistols, and butts of muskets were freely used, the Mexicans retreated in great disorder. The troops that had been faced to the left just before the order to charge was given, immediately found themselves in the midst of a detachment of Mexicans, in a nest of surface quarry holes which gave them protection from distant fire and effectually concealed them from view until we were among them. The struggle here was hand to hand, and sharp for a short time. But they were driven from their quarry holes, back on their main line which gave way, and their own guns were turned upon them before they could get off the field.

Thus, Persifor Smith's brigade, under Colonel Harney, carried, and held possession of, the key-point of the battlefield of Cerro Gordo.

After the battle the various details of engineer soldiers joined in the pursuit of the enemy, were collected together at Encerro, and the company remained with Twiggs' division until it reached Jalapa. At this place it was furnished by the Chief Quartermaster with the finest mule teams in the army. This gave great satisfaction to the men who had struggled so hard to get the engineer train forward, through deep sand, from Vera Cruz. To add to their elation, they had now left the "hot lands" of the coast behind them, had reached a temperate climate, 400 feet above the level of the sea, had escaped the dread *vomito* of Vera Cruz, and had participated closely in the great victory gained by Scott's army at Cerro Gordo.

From Jalapa, Worth's division led the way, the engineer company at its head. During the halt of a few days, at Perote, I procured the transfer of First Sergeant David H. Hastings, from the Third Artillery to the engineer company. He was considered one of the best sergeants in the army, and was at once, made first sergeant of the engineer company. Previous to that time we had only an acting first sergeant. The company entered Puebla with Worth's division, and on the arrival of General Scott at that place we were again ordered to report to general headquarters.

During the three months delay of the army, at Puebla, awaiting reinforcements before moving into the valley of Mexico, the regular instruction of the company—both as infantry and as engineer soldiers—was resumed. Besides the "School of the Sapper" as taught them before they left the United States, the men were now instructed, theoretically and practically, in the "School of the Miner." They were engaged too in work upon the fortifications of Puebla; and had practice in loop-holing walls, and received instruction for placing towns, villages, etc., in a state of defense. Whilst at Puebla the company received the sad news of the death of their Captain.

General Scott, in his official report of the battle of Cerro Gordo, says:

"Lieutenant G. W. Smith led the engineer company as part of the storming force [under Colonel Harney,] and is noticed with distinction." (Ex. Doc. No. 1, p. 263.)

General Twiggs, in his official report of the same battle, states:

"Lieutenant G. W. Smith, of the engineers, with his company of Sappers and Miners, joined Colonel Harney's command in the assault on the enemy's main work, and killed two men with his own hand." (Ex. Doc. No. 1, p. 278.)

In Colonel Harney's official report of this battle it is stated:

"Lieutenant G.W. Smith, of the engineers, with his company, rendered very efficient service in his own department, as well as in the storming of the fort." (Ex. Doc. No. 1, p. 281.)

CHAPTER IV.

FROM PUEBLA TO CHURUBUSCO.

On the 7th of August, 1847, the advance of General Scott's army, Twiggs' division, the engineer company leading, left Puebla and commenced the forward movement into the valley of Mexico. The company served with that division, until Worth's division was placed in the lead during the turning movement made by the army around Lake Chalco. In that movement the engineer company was at the head of Worth's division.

The road ran between the western border of the lake and a high range of hills which, in some places, rose from the water's edge. The road was narrow and rough; and had been obstructed by rolling immense masses of stone upon it from the almost overhanging cliffs. These obstructions were of considerable height; they completely blocked our way; and at several points ditches had been cut across the road.

General Worth directed the Light Battalion, under Colonel C. F. Smith, to advance and drive off the Mexicans who were firing upon us—ordered me to make the road passable for artillery and wagons as soon as possible—and notified me that the leading brigade would assist in that work when called upon. I immediately asked for a detail of 500 men; put them to work, at once, under the direction of the officers and men of the engineer company, and everything was progressing rapidly, when, to my surprise, Lieutenant J. C. Pemberton, aide to General Worth, came up to me and insisted that the whole character of the operations should be changed. Whilst he was elaborating his views I cut him short by asking if he had any orders for me from General Worth. In the meanwhile the latter had reached the front, without either Pemberton or I being aware of his presence. Before the aide had time to reply to my question, General Worth, in a very peremptory tone called out "Come away from there Mr. Pemberton, and let Mr. Smith alone. This is his business—not yours."

In a few hours the road was put in such condition that, by the use of drag-ropes and men at the wheels, we were enabled to pass artillery

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… a little after sunrise, August 19
… my official report of these operations
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… General Scott, in his official report, says
… this afternoon, [August 19th,] the advance
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[illegible] was in the vicinity. I continued some dis- [illegible] and returned without seeing the brigade [illegible] which had, as I understood afterwards, advanced [illegible] the enemy's battery. The reinforcements of [illegible] in our front were rapidly increasing. They [illegible] ten thousand men, on the height, formed [illegible] Towards dark Colonel Riley's brigade returned [illegible] under the command of General Smith; too late, [illegible] for forming the troops to attack the enemy [illegible]. Lieutenant McClellan joined me about [illegible] movement on the village. Lieutenant Foster, who [illegible] became detached with a few of the men, and did [illegible] after the action on the morning of the 20th. [illegible] soon after dark, informed me that the [illegible] would be stormed, [in rear,] at daylight on the [illegible]. This would open the road for artillery, and [illegible] with [the main army under] General Scott [illegible] established. I received orders to hold the engineer com- [illegible] at 3 A. M., and to take my place on the right of [illegible] the morning of the 20th there was considerable delay [illegible] of the brigade [raw troops] under General Cad- [illegible] which General Smith's brigade, now under the command [illegible] Dimmick, First Artillery, was detained very nearly an hour. [illegible] Eleventh Regiment [Cadwallader's brigade] lost its way, [illegible] voltigeurs to halt, thus throwing the brigade under Major [illegible] still further from Riley's, which had moved very soon after [illegible] At the request of General Cadwallader, Major Dimmick [illegible] me to turn over the command of my company to the officer [illegible] and to move forward and conduct the troops that had [illegible] way. The whole force was by sunrise, or little after, halted [illegible] sheltered position in rear of the enemy's battery." (Ex. Doc. [illegible] Appendix, p. 67.)

[illegible] the cause of the delay to General Smith and requested [illegible] to rejoin my company; but he said he desired that I [illegible] remain with him for awhile. By his order, the three brigades [illegible] put in motion. I again asked him to permit me to rejoin [illegible] command. He replied "Not yet" and added, "I will soon [illegible] instructions."

Because of a dense fog the delay in reaching the position in rear of [illegible] Mexican works was no material disadvantage. The fog began to disappear about the time I reported to General Smith. He was then on a ridge at a point about 600 yards in rear of the Mexican works. The three brigades were passing around the extremity of that ridge, several hundred yards in rear of the General. All was quiet in the lines of the enemy. There was another ridge south of the one on which General Smith was standing, and separated from it by a deep and very narrow valley. The sides of both ridges were precipitous; their tops sloped gently to the enemy's line.

General Smith informed me that Riley's brigade would pass partly beyond the extremity of the second ridge; then face to the left, and attack a strong Mexican detachment which was in position on that ridge, several hundred yards in rear of their works. Riley was ordered to drive that detachment and pursue it closely into the Mexican main line. Cadwallader's brigade would go on when Riley faced to the left, and as soon as he passed Riley, Cadwallader would also face to the left and come into action on Riley's right. Smith's own brigade would turn to the left before reaching the extremity of the second ridge. The Third Infantry and First Artillery would advance in the deep valley between the two ridges; whilst the Rifle Regiment, with the engineer company leading, would ascend the steep slope of the second ridge, and get into position on the flank, or rear, of the Mexican detachment which Riley was to attack in front. In the meantime the head of Smith's brigade had come within view, near the foot of the steep slope of the second ridge, and was moving towards the Mexican main line.

General Smith pointed out to me the route to be taken to reach the top of the second ridge; and ordered that the engineer company and rifles should bear to the right, and on getting near the Mexican detachment, remain concealed, and quiet, until Riley's brigade became well engaged; then join in the attack and pursuit of that detachment.

With these specific instructions, I was ordered to rejoin my company; and Lieutenant Beauregard was directed to take general charge of the movements of Smith's brigade. When Beauregard and I reached the top of the second ridge we found we were 50 yards, or less, in rear of the Mexican detachment, which was facing Riley. All was quiet. In a very few moments Riley's fire commenced.

The engineer company, followed by the rifle regiment was then forming in line, under cover, in rear of the Mexican detachment, whose attention was concentrated on Riley, in their front. We were between that detachment and the Mexican works. A small portion only of the Rifle Regiment was in line, when the firing with Riley became very severe, and the order was given for the engineer company and rifles to rise and fire into the backs of the enemy. That fire was very destructive. The Mexicans were astounded; faced squarely about, and in a moment precipitately retreated.

In my official report it is stated that:

"Colonel Riley's advance became engaged with a very strong picket, some 300 yards or more from the rear of the [enemy's] battery, near the crest of the ridge; the engineers and rifles came up at once in position to take the picket in rear, delivered a deadly volley within 50 yards, cheered and rushed on. The enemy's force fled; the head of our column crossed the line of retreat, which brought the right of the column [engineer company and rifles] conducted by Lieutenant Beauregard, in contact with the Seventh Infantry, which formed the left of Colonel Riley's brigade. I went into the enemy's battery with the colors of the Seventh Infantry, my company immediately behind me. The enemy, or at least a portion of them, stood to their guns well, and delivered a fire of grape into our troops when the head of the column was within 25 yards of their pieces. Our troops followed the retreating enemy without halting until they were beyond the reach of our musketry. Lieutenant Beauregard then strongly advised that the troops be halted and formed. A short time afterwards General Twiggs came up. The pursuit was resumed. At San Angel we had an unimportant skirmish." (Ex. Doc. No. 1, Appendix, p. 68.)

* * *

In the pursuit, we passed through the village of San Angel; and near that place, were again halted. During that halt, I noticed a large, high building, in an extensive open field, five or six hundred yards to the North. I was satisfied that from the top of that building with a powerful glass, which was a portion of the engineer company equipment, I would be able to get a good view of the level country for miles around, and obtain quite definite knowledge of the positions and movements of the main Mexican forces.

I communicated my wishes to Major Loring; and asked him if he felt authorized to support the engineer company, with the Rifle Regiment, in a close reconnaissance of the building I pointed out. He laughingly replied; "I have been directed by General Smith to follow you and your company—of course I will go with you."

We had not proceeded more than two hundred yards towards the building when we were overtaken by Lieutenant Van Dorn, Aide to General Smith, who brought an order requiring the Rifle Regiment and the engineer company to return to the head of the column on the road. * * *

A short time thereafter we moved from San Angel to Coyocan, where the head of the column again halted; and was soon joined by General Scott. * * *

AT CHURUBUSCO. The following quotations are taken from my official report:

"Between 12 and 1 o'clock, P. M., [August 20, 1847] I received orders to move, from the village of [Coyocan] immediately after the rifle regiment, on a road intersecting the road from San Antonio to Mexico, in order to cut off the enemy already retreating from San Antonio.

"I had not gone two hundred yards when I received orders to countermarch and move on another route intersecting the road from San Antonio to the city nearer to Mexico. [The latter road led nearly due east, parallel to the front of the earthworks at the Convent, distant from those works about 250 yards.] The regiment of riflemen continued on the road on which I first started. [This road led south-east from Coyocan.] The company took its place [again] at the head of the column [Twiggs' division.] The column was halted by General Twiggs, and I was directed by him to send an officer in advance to see the position of a battery reported to be not far in front. Lieutenant McClellan was sent on one road; and Lieutenant Stevens of the engineers, was directed by General Twiggs to take another. Both officers soon returned and reported a battery in front of a convent, the roof and steeples of which were in plain view of the head of the column and within 700 yards. The roof was crowded with troops; the battery was masked by intervening trees and cornfields. General Twiggs then directed these officers to make a closer reconnaissance and ordered my company as an escort. Having proceeded 500 yards, we saw [Mexican] troops on our right, left, and in front. A lancer was taken prisoner. Lieutenant Stevens directed me to take the prisoner to the General and request an additional escort of two companies. We were at this time about 300 yards from the battery, but it was still almost masked from view. I delivered the prisoner and the message to General Twiggs, and returned at once to my company which I had left in charge of Lieutenant Foster. Lieutenant

Stevens joined General Twiggs whilst I was with him. When I resumed command of the company, Lieutenant McClellan reported to me that *our troops were already engaged in our front;* having, apparently, turned the battery and convent by our right. One of General Twiggs' staff, [Lieutenant W. T. H. Brooks, A. A. Adjutant General, Twiggs' division,] was present and informed us that the rifles with Captain Lee of the engineers, were reconnoitring the same works, and had gone to our right considerably farther from the battery than we then were. We all concurred in opinion that the rifles were engaged with a vastly superior force. There was at this time no firing of artillery. I ordered Lieutenant McClellan to report the result of his observations to General Twiggs. He did so, and on the recommendation of Lieutenant Stevens and McClellan, in which I concurred, the First Regiment of Artillery was ordered to support the rifles. The firing on the right increased; it was evident that several thousands of the enemy were pouring a heavy musketry fire into our troops on the right. The tops of the convent and the surrounding walls were lined with troops; the roof was literally covered. Lieutenant Stevens was of opinion that a few rounds of grape would disperse these masses and relieve our troops already engaged [on the right] from a destructive plunging fire. He went back to the General, leaving myself the senior engineer then in front of the [convent] battery. The fire had now become very brisk upon my [reconnoitring] party; having placed the company under the best shelter at hand, with Lieutenant Foster I proceeded to examine the works to determine the number, character and position of the pieces of artillery. Nothing heavier than a 4 or 6-pounder had yet been fired." (Ex. Doc. No. 1, Appendix, p. 69.) * * *

The force which became engaged, far to our right, before the reconnaissance, supported by the engineer company, fairly commenced, was the advance of Worth's division pursuing the Mexicans who had abandoned their strong works at San Antonio.

Captain James L. Mason, engineer of Worth's division, says, in his official report, that the works attacked by that division, and "so gallantly stormed, had not been reconnoitred."

The engineers in front of the convent, being informed that the rifles with Captain Lee had gone to our right considerably farther from the battery, advised that the rifles be supported by an additional regiment. The same engineers advised that one gun be sent to the front to drive the Mexicans from the roof of the convent, and thus relieve our troops on the right from a destructive plunging fire.

The additional escort of two companies, asked for by the reconnoitring engineers had not come to the front. After Lieutenant Stevens had gone back to General Twiggs, to have one gun with a few rounds of proper ammunition sent forward for the purpose of clearing the roof of the convent, the firing in our front, on the San Antonio road, had materially increased; and the fire from the convent, upon the engineer company, was becoming troublesome. There had been, to me, unexpected delay in bringing the one gun forward; and I determined, as already stated, to place the men under the best shelter at hand, and endeavor to make, in person, a closer examination of the works.

Resuming quotations from my official report—it it therein stated:

"At this time the First Artillery came up to where I was. The lamented and gallant Burke, at the head of the leading company, asked which direction they were to take. I inquired what were his orders. He said that the regiment was ordered to support the Rifles. I pointed to the smoke, which was all we could see by which to determine the position of our troops engaged in a cornfield on our right; told him that they reached their present place by moving farther to the rear, out of range of the works; and remarked to him that the fire through which he would have to pass in the direction he was going was very severe. He replied that they were ordered to move by that road to support the Rifles. The First Artillery filed by and soon encountered, at a distance of 150 yards from the enemy, the heaviest fire of artillery and musketry, followed almost immediately after [by that] brought to bear upon Taylor's battery, which had been ordered to fire upon the convent; and, in selecting a place suitable for managing the guns, had most unfortunately been placed, entirely exposed, directly in front of a well constructed battery with heavy pieces firing in embrasure.

"As the First Artillery filed by me, I ordered my company to be formed, determined to go on with the reconnaissance; and if possible, send back to the General, [Twiggs,] accurate information in reference to the works of the enemy and the position of our own troops, which at that time I could not understand. In moving forward, I was opposite the centre of the [First] Artillery which inclined more to the left, towards the battery, whilst I kept nearer the [principal road leading almost due east from Coyocan.] The ground was level, but some shelter was afforded to small bodies of men, by the ditches, maguey plant, etc. I ordered my men to separate, to shelter themselves as much as possible, [and] to keep within supporting distance of me. I proceeded about two hundred yards. I ordered every man to shelter himself in a small ditch which was fortunately near us; immediately after I heard the fire of Taylor's battery passing directly over my head. [When that fire commenced we were] in the cornfield, about half-way between Taylor's battery and the enemy. Requiring my command to lie close, with Lieutenant Foster, I made my way to an old ruined wall in the open space east of the cornfield, and from that position sent Lieutenant Foster to General Twiggs to report the extent of the line engaged on the right, that we were directly in front of the works [which were now in plain view,] and that, in my opinion, the whole force under General Twiggs' command should turn the enemy's position by our left. Another battery [of the enemy] was seen distinctly to our right and far in rear of the Churubusco battery, apparently enfilading our line engaged on the right. General Twiggs had already sent Colonel Riley's brigade to turn the position by our left, and take the battery by the gorge. When Lieutenant Foster returned, I withdrew the company to a position of more safety, and joined General Smith and Lieutenant Stevens, who were near the place from which I started with the First Artillery. I remained there [under General Smith's order] until after the action.'' (Ex. Doc. No 1, Appendix, pp. 70-71.)

That point was about 300 yards south-west of the convent. There were several adobe houses near, and from it a road along which there were some huts, led to the convent, and another road, almost due east, passed in front of the convent. In moving forward I had kept nearer the latter road, the First Artillery nearer the former. The point I reached in the open, east of the cornfield, was within less than 100 yards of the works at the convent, and there was every indication that these works did not extend along the western side of that building.

The place at which I joined General Smith and Lieutenant Stevens, after I returned from beyond the cornfield, was that at which it had been proposed to place one gun, under cover of the adobe hut; run it out by hand; fire, and run it under shelter again to reload. By this means, a few rounds of grape, canister and shrapnel could have cleared the roof of the convent.

In more senses than one, the firing of Taylor's battery through the ranks of the engineer company, in the cornfield, was a surprise to me. I learned from Lieutenant Stevens that, when he applied for one gun to be sent to the front, those in authority had deemed it best to send forward a whole battery, and place it in an open field, square in front of the fortifications.

The battle of Churubusco was commenced, and mostly fought, haphazard, against the front of the Mexican fortified lines, without giving time for proper reconnaissance.

General Scott, in his official report of the battle, says:

"Lieutenant Stevens of the engineers, supported by Lieutenant G.W. Smith's company of sappers and miners, of the same corps, was sent to reconnoitre the strongly fortified church or convent of San Paplo in the hamlet of Churubusco—one mile off [from Coyocan.] Twiggs with one of his brigades [Smith's, less the rifles] and Captain Taylor's field battery, were ordered to follow and to attack the convent. Major Smith, senior engineer, was despatched to concert with Twiggs the mode of attack, and Twiggs' other brigade [Riley's] I soon ordered to support him." (Ex. Doc. No. 1, p. 309.)

Major John L. Smith, senior engineer, says:

"Lieutenant Stevens in the reconnaissance of the position of Churubusco, was assisted by Lieutenant McClellan and escorted by the company of sappers and miners. This company also participated in the operations of the right [of Twiggs' division.]" (Ex. Doc. No. 1, p. 353.)

Major Dimmick, commanding the First Regiment of Artillery, says:

"About 12 o'clock, M., the battalion was ordered to attack the position of the enemy at the church, reported by the engineers at the time to have but one piece of artillery. The point of attack selected by the senior engineer officer was masked by a cornfield, in front of which I deployed the battalion and ordered it to advance, when almost instantly a shower of musketry, grape and round shot poured upon us, under which the battalion advanced.

"The right had advanced to within one hundred yards of a regular bastion front, the curtain of which had four pieces in embrasure, besides nearly a thousand infantry, both of which kept up such a constant stream of fire that I could not advance further in line; I therefore ordered the men to cover themselves as well as possible. The left of the battalion advanced to within seventy yards of the work, being exposed to the fire of two pieces of artillery, *en barbette*, in addition to the fire of a considerable force of infantry, and some of them still nearer, so that they had a destructive fire on the cannoniers and infantry; which position the battalion maintained until the enemy were driven from their guns and bastion, when they were followed into their work and surrendered." (Ex. Doc. No. 1, Appendix, p. 78.)

Captain Francis Taylor, commanding light battery, says:

"On reaching Churubusco, we came in sight of a church, where the enemy was posted, having, as was supposed, an entrenched battery thrown across the road. Troops were soon thrown forward to attack this place; and, after a short time, I was ordered to place the battery in a position where it was thought I could drive the enemy from the roof and walls of the church, and sustain the other troops in their efforts to carry this place by storm. On taking the position assigned me, I found we were exposed to a most terrible fire of artillery and musketry, of a regular entrenchment, covering the front of the church to which we were opposite, and which the intervening Indian corn hid from our sight at the time. Here I opened my battery, and it was served with great precision for about an hour and a half, notwithstanding it was exposed, during that time, to a constant shower of grape, round shot, shell and musketry. At last, finding my loss was becoming very great, and having succeeded in driving the enemy from the roof and walls of the church, and given to our troops such support as was in my power, I determined to withdraw the pieces." (Ex. Doc. No. 1, Appendix, p. 73.)

The connection between the reconnaissance of the engineers, and the operations of the First Artillery and Taylor's battery at Churubusco, has already been described in extracts taken from my official report.

In his official report, General Persifor F. Smith says:

"Lieutenant G. W. Smith, in command of the engineer company, and Lieutenant McClellan, his subaltern, distinguished themselves throughout the whole of the three actions [19th and 20th, at Contreras; and at Churubusco.] Nothing seemed to them too bold to be undertaken, or too difficult to be executed; and their services as engineers were as valuable as those they rendered in battle at the head of their gallant men. Lieutenant Foster, being detached from his company during the action at Contreras, did not fall under my notice; but in the action on the 19th and at Churubusco, he was equally conspicuous for his gallantry." (Ex. Doc. No. 1, p. 332.)

General Twiggs, in his official report, says:

"To Lieutenant G. W. Smith, of the engineers, who commanded the company of sappers and miners, I am under obligations for his services on this and on other occasions. Whenever his legitimate duties with the pick and spade were performed, he always solicited permission to join in the advance of the storming party with his muskets, in which position his gallantry, and that of his officers and men, was conspicuously displayed at Contreras as well as Cerro Gordo." (Ex. Doc. No. 1, p. 325.)

CHAPTER V.

CAPTURE OF THE CITY OF MEXICO.

During the armistice, which was entered into just after the battle of Churubusco, and terminated on the 6th of September, the engineer company was quartered in the village of San Angel. On the 7th of September I received orders to move the company, its train, and the general engineer train of the army to Tacubaya.

MOLINO DEL REY. That night I was ordered to detail an officer and ten men of the engineer company to report to General Worth. Lieutenant Foster was placed in charge of this detail. He and his men were on the right of the storming party of five hundred picked men, of Worth's division, which led the attack against Molino Del Rey on the morning of the 8th. In that attack Lieutenant Foster was very severly wounded and disabled.

CHAPULTEPEC. On the 11th of September, I received orders to furnish details of men from the company to assist engineer officers in supervising the construction of batteries against Chapultepec. I was placed in charge of Battery No. 1, on the Tacubaya road, against the southern face of the Castle; and Lieutenant McClellan in charge of Battery No. 2, against the southwestern angle. On the night of the 12th, the details were all called in, and I was directed to furnish implements to the different storming parties which were to assault the castle of Chapultepec on the morning of the 13th.

SAN COSME GARITA. At 3 P. M., that day, I received orders to join the siege train, and report to General Worth whose column was to attack the city by the San Cosme route.

At 4 P. M., I reported to General Worth, who was then with his forces, in the suburbs of the city, on the San Cosme causeway, at the point where it changes direction, at an angle of nearly ninety degrees, and is then nearly straight for about six hundred yards to the fortified Garita in our front. He informed me that Lieutenant Stevens had just been severely wounded and this made me the senior engineer with Worth's division. He directed me to go forward in person, closely examine the condition of affairs at the front, endeavor to determine the best method of operating against the fortified Garita, and report to him the result of my observations as soon as possible. He directed me, particularly, to have in view the question whether it would be advisable to bring the siege guns forward against the embrasured battery at the Garita. Just as I was leaving him, he said: "If you find there are two different methods by which the Garita can be carried, one in a shorter time at a sacrifice of men, the other in longer time, but a saving of men, choose the latter." And he added, "There have been too many valuable lives, of officers and men, lost recently in my division, for nothing."

Though he did not specify the action referred to, he meant the battle of Molino Del Rey. Under these instructions, I proceeded to the extreme front, made the requisite examination of our position and that of the enemy, and soon came back. I reported that the houses on the left of the causeway were built up continuously to the battery at the Garita, we could easily break through the walls from house to house; and, under perfect cover, reach the top of a three-story building, with flat roof and stone parapet, within 40 yards of the battery. A fire of musketry from that roof would make the works untenable; and we could thus in a short time drive the enemy from the fortified Garita, and secure a good lodgement within the city, without material loss and without using the siege guns.

General Worth directed me to bring forward the engineer company, which was with the siege train a short distance to the rear, and commence operations on the proposed plan; and at the same time ordered that Clarke's brigade should render any assistance I might call for.

An hour or more before sunset we reached the top of the house above referred to. From that position the inside of the enemy's works could be plainly seen almost to the foot of the interior slope of the parapet. Our first fire upon the Mexicans, who were unconscious of the impending peril, was very deadly. Those who were not killed or disabled by that fire seemed dazed for an instant; but in a few moments, they precipitately retreated, leaving the San Cosme Garita without a single defender in the works. One of their pieces of artillery was withdrawn a few hundred yards, but was then abandoned.

Immediately after that first fire, a portion of the force with me on the roof became engaged with the enemy who appeared on house tops in rear of their battery. We soon drove them from their position. The other portion of our men fell back to the stairs, made their way to the lower story, broke open the thick, heavily barred, strong door, passed into the street, entered the abandoned works, and pursued the enemy. In the meantime, some of our troops from the right of the causeway had come forward and, a very small number of them, were slightly in advance of us in reaching the abandoned battery.

Colonel Garland, commander of the first brigade of Worth's division, on the right of the causeway, says, in his official report:

"The enemy then took position at the Garita San Cosme, where they were supported by two pieces of artillery which raked the streets with grape and canister. Finding a secure position to the right of the second defense, [about 350 yards in front of the Garita,] I reorganized the command as it came up; mounted a howitzer on the top of a convent, which, under the direction of Lieutenant [U. S.] Grant, Quartermaster, 4th Infantry, and Lieutenant Lendrum, 3d Artillery, annoyed the enemy considerably. About this time, report was made to me that considerable progress had been made by the troops on the other side of the street by means of crowbars and pick-axes, working through houses and yards. This caused me to watch closely for the first movement of the enemy indicative of retreat. The moment this was discovered, the 4th Infantry, followed by detachments of the 2d and 3d Artillery, under Colonel Belton, rushed up the road, when they entered the works simultaneously with the forces operating to the right and left, Captain McKenzie's storming party slightly in advance." (Ex. Doc. No. 1, Appendix, p. 170.)

Referring to this operation, General Worth, in his official report, says:

"The moment had now arrived for the final and combined attack upon the last stronghold of the enemy in my quarter; it was made, by our men springing, as if by magic, to the tops of the houses into which they had patiently and quietly made their way with the bar and pick, and to the utter surprise and consternation of the enemy, opening upon him, within easy range, a destructive fire of musketry. A single discharge, in which many of his gunners were killed at their pieces, was sufficient to drive him in confusion from the breastworks; when a prolonged shout from our brave fellows announced that we were in possession of the Garita of San Cosme, and already in the City of Mexico." (Ex. Doc. No. 1, p. 392.)

The American army having thus captured the fortifications of the capital of the enemy's country, a magnificent city of nearly 200,000 inhabitants, a secure lodgement was immediately effected in large houses, on the left of the street, a few hundred yards from the Garita.

I then proceeded, with the engineer company and an infantry detachment, several hundred yards farther; and found a strong position on the right of the street where the troops could rest protected from fire. Going farther to the front, I discovered that, 150 yards in advance there was a large convent, on the left of the street, occupied by a strong force. The next cross street, the Paseo, had batteries upon it. These facts were reported to General Worth, who ordered forward two brigades—one to occupy each of the positions selected—and, directed me to place those troops, station the picket-guards, and then, with Lieutenant McClellan, report at his headquarters which was several hundred yards within the Garita.

The aqueduct, in the middle of the street along which we advanced, was an open stone trough, supported at a height of ten feet, or more, by pillars and arches. There was a good deal of firing down the street from Mexican detachments; but, by taking shelter under the arches, between the pillars, our men, in small groups, were quite well protected. A little before dark, whilst I was under one of the arches at the extreme front, endeavoring to get a closer view of the enemy at the convent and on the Paseo, I was joined by Lieutenant Sydney Smith, of the Fourth Infantry, who had borne several messages from me to General Worth during the afternoon. In a few moments after he joined me we heard horses feet rapidly approaching us from the direction of the citadel. These horsemen were captured, and proved to be three Mexican officers, one of whom was Adjutant-General on the staff of Santa Anna.

Accompanied by Lieutenant McClellan, I reported to General Worth at 10 P. M., and was ordered by him to suspend operations for the night and resume them at daylight. * * *

Being awakened by one of General Worth's aides, I asked if it was already 3 o'clock. It seemed to me that I had not been asleep five minutes. The aide said, "it is about 1 o'clock. A deputation from the civil authorities has just informed General Worth that Santa Anna's army evacuated the city before midnight, and they offered to surrender the city. They have been passed on to General Scott, at Tacubaya; and General Worth wishes to see you at once."

The latter told me more fully about the deputation and their proposal to surrender; expressed some doubt in reference to the evacuation of the city by the Mexican army; directed me to return to the front; take the engineer company and a detachment of infantry; proceed carefully forward, using every precaution; and report to him the slightest indication that the city had not been evacuated. I was directed to examine closely every large building and strong position along our route; and not pass them until thoroughly satisfied that they were not occupied by Mexican soldiers.

This forward movement commenced about 2 A. M. There was some delay in determining whether the strong convent, mentioned above, had been evacuated. Accounts on that subject were conflicting; but a thorough examination of the whole position showed that it was abandoned. I reported that fact to General Worth, and informed him that we would move on with great care, in strict compliance with his instructions.

All buildings of importance were broken open. None of them were occupied by the enemy. From time to time, I reported these facts to General Worth; and, at daylight, I informed him that, from a church steeple near the Alameda, I could see that the Citadel, which had stopped the advance of General Quitman's troops early in the afternoon of the 13th, was deserted. At that time, Lieutenant McClellan reported to me there were no signs of the enemy in any portion of the Alameda; and I suggested to General Worth that his whole division be moved forward.

In the meantime, with the engineer company and the infantry detachment, I passed beyond the Alameda, breaking open, as before, and examining all strong buildings on our route. We had gone more than two blocks in advance of the Alameda, and were closely approaching the Main Plaza and the National Palace, when I received a positive order to countermarch my command, and report to General Worth at the Alameda. I demurred, and told the aide, who bore the order, that I had obeyed all of General Worth's cautionary instructions; that there was no enemy in our front, and no reason for calling us back. The aide replied, "the order is positive. You must go back." I then gave the order to countermarch.

A few days later I learned from General Worth that he received a peremptory order from General Scott not to permit anyone under his command to pass beyond the Alameda, until further instructions were received from the General-in-Chief.

For several hours after the engineer company took its place on the right of Worth's division, at the Alameda, all seemed to be quiet in the city. General Quitman's troops, from the Belen Gate, had passed the abandoned citadel, reached the Main Plaza, and took possession of the National Palace. Later, General Scott, with his staff officers and mounted escort, entered the city.

About that time a shot was fired, evidently aimed at General Worth, from a narrow street or lane, opposite the head of the division. The shot missed General Worth, but very severely wounded Colonel Garland. General Worth, immediately ordered me to take the engineer company, go into the lane, find the man who fired the shot, and hang him. * * *

In less than an hour after Colonel Garland was wounded, lawless bands of armed Mexicans commenced firing from the parapet roofs of houses, from church steeples and windows, in various parts of the city, upon our troops in the open streets. An order was then given, by General Scott, for Worth's forces to move beyond the Alameda and join with the rest of the army, in putting down the rising of armed outlaws who made this murderous attack upon us eight or ten hours after the city surrendered. In these operations the engineer company was with Worth's division until the recall was sounded late that afternoon.

General Scott, in his official report, says:

"I communicated, about daylight [on the 14th,] orders to Worth and Quitman to advance slowly and cautiously [to guard against treachery] towards the heart of the city, and to occupy its stronger and more commanding points. Quitman proceeded to the great plaza or square, planted guards and hoisted the colors of the United States on the National Palace, containing the halls of Congress and executive apartments of Federal Mexico. In this grateful service, Quitman might have been anticipated by Worth, but for my express orders halting the latter at the head of the *Alameda*, [a green park] within three squares of that goal of general ambition." (Ex. Doc. No. 1, p. 383.)

General Worth, in his official report, says:

"At 5 A. M., on the 14th, my troops and heavy guns advanced into the city, and occupied the Alameda to the point where it fronts the palace, and there halted at 6 o'clock, the General-in-Chief having instructed me to take a position and await his further orders. Shortly afterwards a straggling assassin-like fire commenced from the housetops, which continued, in various parts of the city through the day, causing us some loss. The first shot, fired at a group of officers at the head of my column, struck down Colonel Garland, badly wounded. About the time of our entrance into the city, the convicts in the different prisons, to the number of some thirty thousand men, were liberated by order of the flying government, armed and distributed in the most advantageous houses, including the churches, convents, and even the hospitals, for the purpose of exciting, if possible, the city to revolt."

In speaking of the general operations of his forces in the capture of the city, General Worth adds:

"Officers and men of every corps carried themselves with wonted gallantry and conduct. Of the staff; Lieutenants Stevens, Smith, and McClellan, engineers, displayed the gallantry, skill and conduct, which so eminently distinguished their corps." (Ex. Doc. No. 1, pp. 393-4.)

General Scott adds:

"Captain Lee, engineer, so constantly distinguished, also bore important orders from me [September 13th] until he fainted from a wound and the loss of two nights' sleep at the batteries. Lieutenants Beauregard, Stevens and Tower, all wounded, were employed with the divisions, and Lieutenants G. W. Smith and G. B. McClellan with the company of sappers and miners. Those five lieutenants of engineers, like their captain, won the admiration of all about them." (Ex. Doc. No. 1, p. 385.) * * *

The capture of the city, and its occupation by General Scott's army, virtually ended the war made by the United States against Mexico.

CHAPTER VI.

IN THE CITY OF MEXICO—RETURN TO WEST POINT.

After the street fighting on the 14th, the city was quiet and remained so. The men of the company were fairly entitled to a good rest and a new outfit of clothing; but the quartermaster could not then furnish the latter. At their request, I authorized them to purchase a better quality of cloth than that furnished by the government, and to have finer material for trimmings than the coarse cotton braid allowed by the regulations. The clothing was made by good tailors and paid for by the men. In the course of a month or six weeks, the company was provided with handsome, well-fitting uniforms.

In the meantime, drills were suspended for about a month. During that period the only duty required of the men, other than that of ordinary guard over their quarters and the engineer train of the army, was that of details to assist engineer officers in making surveys of the recent battle-fields.

In the latter part of October, the surveys of the battle-fields being completed, and the men provided with new and well-fitting uniforms, infantry drills were resumed. An order was issued requiring the company to be formed without arms, the next day, in the Alameda, for squad drill. * * *

It is safe to say that within six weeks from the time squad drills without arms were commenced in the engineer company, in the City of Mexico, that company as Infantry, was better drilled than any other in the army. In that respect, and in discipline, they were pattern soldiers. Regular instruction in the "School of the Engineer Soldier" was then resumed.

From raw recruits, on the Rio Grande, disturbed by the epithet, "pick and shovel brigade" applied to them, at that time, by the soldiers of the line, the engineer company had become veterans of more than half a dozen important battles; had always been in the front of the fighting; and had often been called upon to direct large working parties of soldiers, detailed to use the "pick and shovel."

The following extracts from correspondence, and from my monthly reports, give a brief official account of the affairs of the company after the capture of the City of Mexico.

On the 4th of October, 1847, I addressed to Lieutenant I. I. Stevens, Adjutant of Engineers, for the information of the senior engineer in the field, and the General-in-Chief, a letter from which the following quotations are taken:

"By the last advices that I have received I learn that only six engineer recruits have been made in the United States since September, 1846. During that time the effective strength of the company in the field has been reduced from seventy-one to thirty-six. Something must be done. I have endeavored to re-enlist good men whose terms of enlistment in other corps had expired; I have tried to get transfers of good men, and succeeded in obtaining but one. The senior engineer, believing that more could be done, attempted it himself—he procured none.

"At Vera Cruz my men were worked too hard; many of them are suffering yet from disease contracted there. Time, labor and life would have been saved if we had had the proportion of engineer soldiers usual in the armies of civilized nations. At Cerro Gordo, when I could furnish ten men [for details,] fifty, at least, were necessary. In the operations in this valley, the same necessity has been felt for a larger number of soldiers of this character. There ought to be more companies of engineer soldiers in this army. Certainly, measures should be taken to complete the number of men allowed in the only company now authorized. I know of none so likely to succeed as sending an officer and non-commissioned officers [to the United States] on this duty."

In my official report for the month of November, 1847, it is stated:

"The system of instruction now being pursued is the following:

From 9 A. M. until 10:45 A. M., recitations and instruction of the whole company, under direction of both officers, in *Manuel du Sapeur*, together with lectures and recitations on field fortifications. From 11 A. M. until 12:30 P. M., [infantry drill.] From 2 P. M. until 4 P. M., recitations in arithmetic and practice in writing. Each officer has a section in arithmetic, and gives a general superintendence to a section in writing. Instruction in writing is given by sergeants.

"I have nothing new to offer either in reference to the property, the enlistment of men, or the settlement of the accounts of the late Captain Swift. All, in my opinion, matters of importance; but already referred to, [in previous reports and correspondence,] perhaps, too often.

"It is just one year since, by the casualties of service, the command of this company devolved upon myself as the senior officer for duty with the engineer troops. During this time the interests of the general engineer service, particularly of the non-commissioned officers and men, have materially suffered for want of an officer of rank at the head of the company. In the French service *two* captains are assigned to every company of this character, and the companies are all [well] instructed before they take the field. I earnestly recommend that four officers of engineers be assigned to duty with this company. The commander should be an officer of rank; his position permanent. In case the Chief Engineer should order an officer into the field to take command of Company A, Engineers, I respectfully request that I may be ordered to the United States as soon as relieved from this duty."

On the 1st of February, 1848, I reported that the course of instruction, adopted for the company, "had been continued, with satisfactory progress on the part of non-commissioned officers and men." * * *

In my official report for the month of March, 1848, it is stated:

"During the month, daily instruction [of the company] in branches pertaining to engineering has been omitted. I have thought it best to pay more attention to their improvement in writing and arithmetic. The infantry exercises are continued."

On the 1st of May, 1 reported, "during the month of April the course of instruction and drill pursued in March has been continued, with satisfactory results." * * *

When it became generally known in the army that the Mexican Government had agreed to the proposed treaty of peace, and that the formal ratification would soon be consummated, I requested the senior engineer, Captain R. E. Lee, to direct me to sell the tools, etc., of the engineer train, in the City of Mexico; order me to proceed to the coast by the first opportunity, for the purpose of looking up, and accounting for, a large amount of engineer poperty for which the estate of the late Captain A. J. Swift was responsible; and authorize me to turn over the command of the engineer company to Lieutenant McClellan, when I started for the coast.

In compliance with Captain Lee's instructions, the tools were sold. They brought more than they had originally cost in the United States. I left the City of Mexico the day the treaty of peace was signed on the part of the Mexicans; and accompanied General Persifor F. Smith to Vera Cruz, at which place he was charged with making all preparations for the transportation of the army to the United States. Before leaving the City of Mexico I turned over the command of the engineer company to Lieutenant McClellan. I was detained in Vera Cruz about two weeks, obtaining information in regard to, and making disposition of, the public property in that vicinity, for which Captain Swift's estate was then held responsible.

The accounting officers of the government, in Washington had charged against him, on their books, the value of large amounts of property which had been shipped to, but never received by him. Several vessels, partly loaded with portions of that property, were shipwrecked by northers during the siege of Vera Cruz. In the time I spent at that place after the war ended, I obtained knowledge which enabled me to clear up all accounts against the estate of Captain Swift. The amount of that nominal indebtedness far exceeded the value of his property; which would have been unfairly sacrificed to the government, and have left his name unjustly tarnished as that of a defaulter, if conclusive evidence of the facts in the case had not been furnished to the accounting officers.

The engineer company, under Lieutenant McClellan, accompanied by all the engineer officers from the City of Mexico, left that city on the 28th of May, 1848, and marched to Vera Cruz. From the latter place the company was transported by steamer to New York City; arrived at West Point, N. Y., on the 22d of June; reported to the superintendent of the Military Academy, and was immediately ordered to report to Captain George W. Cullum, of the engineer corps, as its new commander. I remained about a week in Vera Cruz after the company sailed; arrived at West Point in July; and was ordered to report to Captain Cullum.

A short time thereafter, I asked to be relieved from duty with the company; and applied for six months leave of absence. The leave was granted, and it was understood that, on its expiration, I would been ordered to other engineer service.

Before the expiration of my leave, the war men of the company procured the passage of an act by Congress, authorizing their discharge from the service Under that act nearly all the men of the company who had served in Mexico, immediately obtained their discharge from the army. This virtually reduced the company to the detachment of recruits which had been collected and retained at West Point.

At the expiration of my leave of absence I was formally relieved from further direct service with the engineer company; and at the request of the Chief Engineer, consented to undertake the enlistment of new recruits to fill the places in the company vacated by the war men, who had been discharged. That business was finished within a few months. I was then ordered on other engineer duty and, thus my connection with the engineer company ended.

EULOGY *on the late* JOSEPH G. TOTTEN,

BREVET MAJOR GENERAL.

Late Chief Engineer U. S. Army, and Regent of the Smithsonian Institution.

By J. G. BARNARD,
Lieutenant Colonel of Engineers,
and Brevet Brigadier General U. S. Army, Brigadier and
Brevet Major General U. S. V., A. M., LL. D., N. A. S.

[Reprinted from the Annual of the National Academy of Sciences for 1866.]

[Instead of preparing a eulogy myself, as requested by the Board of Regents, of their lamented associate General Totten, I have thought the service would be better rendered by presenting the facts I had gathered on the subject to General Barnard, and by adopting his tribute to the memory of one so long and so efficiently connected with the Institution. J. H.]

Mr. President and Gentlemen of the Academy:

In conformity with a clause of the constitution of this Academy, and in obedience to your instructions, I am here to render the tribute of a formal biographical notice in commemoration of one who was numbered among our most venerable and most honored associates. If, in the language of one of our body, on a previous and similar occasion, "it is no unreasonable assumption that public benefit and individual incentives may be derived from the history of any man whose scientific services have rendered him worthy of admittance to your number," that assumption must have a peculiar force when it applies to one who has "finished his course," and has filled a life, protracted beyond the usual term, with scientific labors of no ordinary variety and magnitude.

It is but little more than two years since we first met for the great and important work of organizing this National Academy, and with us—of our number, if not personally present—were "both the gray-headed and very aged men." But, alas! these, like autumnal leaves, are rapidly falling away, and already the places of a Totten, a Hitchcock, and a

Silliman know them no more, save in the records of their lives and deeds, and in the grateful memories of their associates. What a trio of names, glorious in the annals of science, is this! Well may they be incentives to us who yet remain to strive that we may worthily replace them, and establish for this Academy a reputation for usefulness and science which their honored bearers have acquired for themselves.

Although there may be many among us more capable than myself of doing justice to the memory of our departed colleagues, I feel grateful that the lot has fallen to me. Placed under General Totten on my first entrance into the military service—almost in my boyhood—my relations to him, both personal and professional, have ever since been continuous and intimate. Under obligations to him of no ordinary nature, I could not do otherwise than regard him with reverence and affection. If I fail, therefore, it shall not be because my heart is unmoved, nor because I am insensible to the magnitude of my task.

JOSEPH GILBERT TOTTEN was born in New Haven, Connecticut, on the 23d of August, 1788. His grandfather, Joseph Totten, came from England before the war of the Revolution, and engaged in mercantile pursuits in New York. Attached to the cause of the mother country, he left that city, after the acknowledgment of our independence, for Annapolis, Nova Scotia. It would appear that his two sons remained in this country, since one of them, Peter G. Totten, married in 1787 Grace Mansfield, of New Haven, a very beautiful woman, who died a few years after her marriage, leaving two children, the subject of this memoir and a daughter, Susan Maria, who married Colonel Beatty, an English officer, and who is still living, a widow, in London. After the death of Mrs. Totten, which occurred when her infant son was but three years old, the father, having been appointed United States consul at Santa Cruz, West Indies, took up his future abode on that island, leaving his son under the care of his maternal uncle, Jared Mansfield, a graduate of Yale College, 1777, and a learned mathematician. The boy continued to be a member of Mr. Mansfield's family until the latter removed to West Point, having been appointed captain of engineers and a teacher in the United States Military Academy, then just organized by act of Congress of 1802. Young Totten's first teacher was Mr. Levi Hubbard, brother to the rector (at that time) of Trinity church, New Haven; afterwards his education was carried on under the personal superintendence of his uncle. Of the period of his schoolboy life we have some glimpses, through the recollections of an old friend and schoolmate, Mr. Ralph Ingersoll of New Haven, who speaks of him as a bright, noble youth, of fine mind, fond of study, and always at the head of his class, gentlemanly in his deportment, and greatly beloved.

Young Totten went to West Point with the family of his uncle in 1802. He was soon after appointed a cadet. He remained at West Point one term, that of 1803, and perhaps part of that of 1804. He was promoted to a second lieutenancy in the corps of engineers, July 1, 1805.

The venerable General J. G. Swift, recently deceased, his brother engineer officer and life-long friend, describes him at West Point as "a flaxen-headed boy of fourteen years of age, a good scholar, and to me a most interesting companion."

Captain Mansfield, having been appointed surveyor general of Ohio and the western Territories, November 4, 1803, induced his nephew to accompany him to the west as an assistant on that first systematic survey of any of the new States of the Union. Here that faculty which so distinguished him through life, of keen observation of whatever was most interesting connected with or incidentally brought under his notice by his professional pursuits, displayed itself at this early age in a noteworthy manner. The vestiges of an earlier race than the red man, which have since been made the subject of the researches of a Squier and a Davis, of a Lapham and of a Haven, and to which, during recent times, fresh attention has been directed by the developments of the high antiquity of the human race in Europe as shown by similar relics over the surface of that country and by the lacustrine remains in Switzerland, attracted his notice and were made the subjects of survey. Although these investigations were not published, they are, I believe, the first we have record of; those of Caleb Atwater, who is called by Squier and Davis "the pioneer in this department," not having been published until 1819. Full descriptions and measurements of several of these mounds, particularly that of Circleville, were made and sent to his friend, J. G. Swift. To most youths of his age those remains of structures, built

> "while yet the Greek
> Was hewing the Pentilicus to forms
> Of symmetry, and rearing on its rock
> The glittering Parthenon,"

would have been passed over with vague curiosity or listless indifference. Not so with young Totten. Although not able, perhaps, to perceive all the ethnological importance which has since been attached to them, he could yet appreciate them as objects of high interest, as vestiges of the races which had inhabited the country, and give his time to their examination and measurement.

During the two years which he passed in the office of his uncle at Ludlow's station near Cincinnati, he was a companion of several young men who subsequently became conspicuous, among whom were Nicholas Longworth, Samuel Perry, Daniel Duke, Thomas Pierce, and Peyton Symmes, all of whom are now dead. His tastes, however, led him back to the army, (from which he had resigned shortly after his promotion,) and, Februrary 23, 1808, he was reappointed a second lieutenant of engineers, his commission bearing the same date as that of his subsequent friend, brother engineer officer, and professional associate, Sylvanus Thayer, of national fame as for so many years superintendent of the Military Academy, and as the officer for whom is mainly due its present high grade among the military and scientific institutions of the world. Lieutenant Totten commenced his career as a military engineer under Colonel Jonathan Williams, the first chief of the corps, and was engaged on the construction of Castles Williams and Clinton, New York harbor.

At the commencement of the war with England Lieutenant Totten was assigned to duty as chief engineer of the army under Brigadier General Van Rensselaer, in the campaign of 1812, on the Niagara frontier, and in that capacity took a conspicuous part in the battle of Queenstown. He was subsequently chief engineer of the army under the command of Major General Dearborn, in the campaign of 1813, and of the army under Major General Izard and Brigadier General Macomb, in the campaign of 1814, on Lake Champlain. Having been promoted to a captaincy in 1812, he was in June, 1813, brevetted major, for "meritorious services," and September 11, 1814, lieutenant colonel, for "gallant conduct at the battle of Plattsburg;" his efficient services as an engineer in the defensive arrangements of that field having contributed powerfully to the successful issue.

The termination of the war may be considered as the close of one period in the life and services of General Totten, and the commencement of another; or rather it may be said, that the events of which we have traced a faint outline were but the preparation and training of his mind for the real work of his life. Reared under the eyes and guardianship of a relative distinguished for his mathematical attainments, receiving as extensive a military and scientific education as West Point at that early day could give, called by his position in Surveyor General Mansfield's office, not only to exercise the science which the duties involved, but to take extended views of our country as to the interconnection of its parts, and their relations to commerce or war, then practically taught the duties of a military engineer in what concerns the defence of harbors, and finally carried through the ordeal of actual war in the campaigns of armies in the field, he was now prepared for the great work of his life—the fortification of our seaboard frontier. When I call this the great work of his life, I am not unaware that it is but a *part* of that work—still the most important part, and one to which his other labors may be considered incidental.

A brief reference to the condition and progress of sea-coast defense at that period is here appropriate. Previous to the Revolution, our seaport towns had not grown into large cities, nor were there great naval establishments or military depots to invite the enterprises of an enemy. During that contest, the harbors of Boston, New York, Philadelphia, Charleston, &c., had been, to a certain extent, "fortified" against naval attack by slight earthen batteries, or in some few cases by small and (as we would now call them) insignificant earthen forts. A work of palmetto logs and sand on Sullivan's Island, Charleston Harbor, mounting but 30 guns, decisively repulsed, early in the Revolutionary war, the attack of the British fleet under Sir Peter Parker, consisting of two frigates and six sloops-of-war, carrying about 270 guns, destroying four of the smaller vessels, and inflicting a loss of 205 killed and wounded (eleven times as many per gun employed against them as the English lost at Trafalgar;) thus decisively demonstrating the value of fortifications, and the superiority of land batteries to ships. But with an immense sea-coast line and sparse population, it was impossible to hold our seaports against the great naval power of the mother country, and the war of the Revolution was mainly a contest of land forces. After the attainment of our independence, the importance of fortifying our harbors impressed itself on the mind of General Washington, and the political agitations which grew out of the French Revolution, and which threatened to involve the new-born Power of the West, prompted early action in this direction. In that day war, though a science, had not grown into one which makes tributary to it all other sciences, as it has since done. Fortification, indeed, had reached a high degree of perfection, but the elaborate treatises on that subject scarcely touched the subject of harbor defense, so little art was apparently supposed to be involved in throwing up batteries to defend the entrances of ports. The art of a Vauban and Cormontaigne was little concerned in the war from which we had just emerged, and the circumstances were too dissimilar, the theatre too large and too thinly populated, the armies engaged too small, to afford to the precepts of a Lloyd or a Templehoff much apparent applicability. While the war developed generals of unquestionable ability in the spheres in which they acted, it seemed to be conceded, that for military science, and especially for the art of fortification, we must look to Europe. Hence we find so many of the early harbor defences of our principal seaport towns to have been built under the direction of foreign officers who had found employment among us, and who did not always possess the knowledge of the art to which they laid claim.

The importance of a Military Academy for the training of officers for the military service, and especially for the engineers and artillery, had been acknowledged even from the very outset of the struggle for independence. We find even the Continental Congress appointing a committee "to prepare and bring in a plan of a Military Academy," and the first Secretary of War, General Knox, in an official report to the President, discusses the subject at much length. The establishment of such an institution is known to have been a favorite object of General Washington, and in his annual message in 1793 he suggests the inquiry, "whether a material feature in the improvement" of the system of military defense "ought not to afford an opportunity for the study of those branches of the art which can scarcely ever be attained by practice alone;" and in 1796 he states that "the desirableness of this institution had constantly increased with every new view he had taken of the subject."

An act of Congress of 1794 had provided for a corps of artillerists and engineers, to consist of four battalions, to each of which eight cadets were to be attached, and made it the duty of the Secretary of War to procure books, instruments and apparatus fot the benefit of said corps; and in 1798 Congress authorized the raising of an additional regiment, increased the number of cadets to fifty-six, and empowered the President to appoint four teachers of the arts and sciences necessary to the efficiency of this "corps." Of the four teachers, none were appointed prior to January, 1801, at which time Mr. George Barron was appointed teacher of mathematics, and the institution, "which was nothing more than a mathematical school for the few cadets then in the service," was nominally established.

It was soon discovered than the regiment of artillerists and engineers could not combine with effect the two duties assigned to its members, and a law was therefore framed separating them into two corps, and declaring that the corps of engineers should be stationed at West Point, New York, and should constitute a Military Academy. This act of March 16, 1802, which is the organic law of the Corps of Engineers and of the Military Academy, provided for the appointment of a certain number of officers and cadets,* (not to exceed twenty in all,) and declared that

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*Besides ten cadets of engineers, forty cadets "of artillery" were authorized by this law; making fifty cadets in all.

"the principal engineer, or, in his absence, the next in rank, shall have the superintendence of the Military Academy, under the direction of the President of the United States."

It is not my purpose here to follow further the history of that institution; I have alluded to its initiation as a step taken to provide for an acknowledged want of the period—an institution for teaching the military sciences to young men entering the army, and for creating a competent *Corps of Engineers*. It was soon found, however, that the duties of engineer officers were inconsistent with their remaining at West Point, and themselves constituting "a Military Academy." Most of them were soon called to duties along the seaboard, in constructing our fortifications, while, as the wants of the service and of the Academy have been more clearly seen, the number of cadets has been increased, to supply not only the engineers and artillery, but officers of all arms of the service, and the various professorships and departments of instruction now existing have been established.

As the duties of the corps became more and more extensive, its chief, though charged with the administration of its affairs, could not be constantly present at the Academy, and it ultimately became apparent that the immediate superintendency of such an institution was incompatible with his proper functions. In 1817, an officer selected from the corps (Brevet Major Sylvanus Thayer, to whom allusion has already been made) was appointed permanent superintendent of the Academy, and made subject only to the orders of the President of the United States.

Major (afterwards Colonel) Jonathan Williams, a near relative of Dr. Franklin, whom he accompanied, as secretaty, to France, where he studied the military sciences, and made himself acquainted with the standard works on fortification, was the first chief engineer of the United States under the law of 1802. He was an officer of decided merit, much beloved by his subordinates, and is justly styled the father of the Corps of Engineers and of the Military Academy.

While exercising his superintendence of the Academy, he devoted himself personally to the fortification of New York Harbor, and most of the forts which constitute the inner line of defense of that harbor—Fort Columbus, Castles Williams and Clinton, (Castle Garden,) and a work similar to the last named, located two or three miles higher up the river (Fort Gansevoort)—were planned by him, and built under his immediate supervision.

Castle Williams was the first "casemated" battery erected in this country, (built in 1807–10,) and was planned after the system of Montalembert, with which, as we have seen, Colonel Williams had made himself acquainted in France. This and other works of Colonel Williams, though they have been superficially and ignorantly criticised, were really meritorious, and do not suffer by comparison with European structures of the same or even much more recent dates.

The indications of an approaching war with England, and the obvious inadequacy of existing fortifications, had led to renewed exertions, and prompted the works just mentioned and others at all our seaports, so that when the war broke out there was not a town of any magnitude upon the coast not provided with one or more batteries. But most of the works so thrown up before the subject had been studied and systematized as a whole were defective in design, small, weak, and, being built, for present economy, of cheap materials and workmanship, very perishable. In the main, however, they answered their purpose—more, perhaps, through an undue respect for them on the part of our foe than through their intrinsic strength. It was not till after the close of the war with England that a permanent system of coast defense was entered upon by our government. Indeed, without the experience of that war it is doubtful whether a measure, always so unpopular and generally so little understood as a national system of fortifications, could have gained the support of Congress and of the people. A "board of engineers" was constituted in 1816, with instructions to make examinations of the sea-coast, and to prepare plans for defensive works, subject to the revision of the Chief Engineer and the sanction of the Secretary of War.

Up to this period the Military Academy had maintained a sort of embryo existence, without definite form or a prescribed system. The annual term of study lasted from April to November, all the intermediate months being vacation. No fixed number of terms was necessary to graduation, nor was it prescribed what should be studied. Some cadets remained but a single term before being commissioned; others, several years. Although this period produced officers who afterwards became highly distinguished in engineering, (as well as in other branches of military art,) it is not surprising that the government yet entertained the common notion that only in Europe, and especially in France, could high military science be found; nor that, in undertaking so vast and costly a work as the fortification of our sea-coast, distrust should have been felt in the unaided abilities of our own engineer officers. A distinguished French engineer, General Simon Bernard, was invited to this country, and, as "assistant" in the Corps of Engineers, (an office created for the purpose by Congress,) made a member of the board which, as first constituted, November 16, 1816, consisted of himself as president, Colonel William McRee, and Lieutenant Colonel J. G. Totten. In 1817 Colonel Totten was relieved, and appears to have been stationed at Rouse's Point, Lake Champlain, in charge of fortifications at that place, and the board to have been composed of Brigadier General J. G. Swift, Chief Engineer, Brigadier General Bernard, and Colonel McRee; but Colonel Totten was again made a member in 1810, and (both General Swift and Colonel McRee having resigned) the permanent board came to consist of Bernard and Totten alone, and the labor of working out the fundamental principles of the system, and of elaborating the projects of defense for the great seaports, thus devolved mainly upon these two officers, though naval officers of rank and experience were associated with them whenever their examinations included positions for dock-yards, naval depots, or other objects which concerned the naval service.

Though the advent of a foreign officer, and his assignment to this duty, under the anomalous designation of "assistant" in the Corps of Engineers, naturally caused some feeling, yet it can scarcely be doubted that the influence of the proceeding was beneficial. If in Swift, McRee, Totten, Thayer, and many others, were found high engineering abilities and acquirements. it is no less true, that professional association with such a man as Bernard was calculated to stimulate to higher attainments and more zealous exertion. The spirit of emulation alone would induce our own officers to prove to the country that they were not inferior to others. To high military and scientific acquirements and great experience in his professional duties, General Bernard united to the qualities of an amiable and acccomplished gentleman the tact to adapt himself to his peculiar position without wounding the pride of those with whom he was thus associated. The prestige of his name aided powerfully in sustaining, with the administration and with Congress, the measures which the board found necessary to recommend, and in establishing firmly, as a part of our national policy, the system of sea-coast defense by fortifications. In recounting the origin and growth of the system, it is but just to give that name an honorable mention.

By the board of engineers of which I have been speaking a series of reports was drawn up, which, mostly from the pen of our departed associate, form his best memorial, and exhibit in a masterly manner the principles of sea-coast and harbor defense, and their application to our own country. In a paper of this kind it will not be out of place to give some idea, at least, of the arguments and views contained in these documents. An elaborate report of 1826, from which I quote, gives a general *résumé* of the principles which have guided the labors of the board, and of the results arrived at:

"The means of defense for the seaboard of the United States, constituting a system, may be classed as followed: First, a navy; second, fortifications; third, interior communications by land and water; and fourth, a regular army and well-organized militia.

"*The navy* must be provided with suitable establishments for construction and repair, stations, harbors of rendezvous, and ports of refuge, all secured by fortifications defended by regular troops and militia, and supplied with men and materials by the lines of intercommunication. Being the only species of offensive force compatible with our domestic institutions, it will then be prepared to act the great part which its early achievements have promised, and to which its high destiny will lead.

"*Fortifications* must close all important harbors against an enemy, and secure them to our military and commercial marine; second, must deprive an enemy of all strong positions where, protected by naval superiority, he might fix permanent quarters in our territory, maintain himself during the war, and keep the whole frontier in perpetual alarm; third, must cover the great cities from attack; fourth, must prevent as far as practicable the great avenues of interior navigation from being blockaded at their entrances into the ocean; fifth, must cover the coastwise and interior navigation by closing the harbors and the several inlets from the sea which intersect the lines of communication, and thereby further aid the navy in protecting the navigation of the country; and sixth, must protect the great naval establishments.

"*Interior communications* will conduct with certainty the necessary supplies of all sorts to the stations, harbors of refuge, and rendezvous, and the establishments for construction and repair, for the use both of the fortifications and the navy; will greatly facilitate and expedite the concentration of military force and the transfer of troops from one point to another; insure to these also unfailing supplies of every description, and will preserve unimpaired the interchange of domestic commerce even during periods of the most active external warfare.

"*The army and militia*, together with the marine, constitute the vital principle of the system.

"From this sketch it is apparent that our system of defense is composed of elements whose numerous reciprocal relations with each other and with the whole constitute its excellence; one element is scarcely more dependent than the whole system is on any one. Withdraw the navy, and the defense becomes merely passive; withdraw interior communications from the system, and the navy must cease in a measure to be active for want of supplies, and the fortifications can offer but a feeble resistance for want of timely re-enforcements: withdraw fortifications, and there only remains a scattered and naked navy."

The relation of the navy to fortifications is one of those subjects not always well appreciated, and hence the cause of mischievous notions and much misrepresentation. No pains is spared in these reports to make this subject clearly understood. After the quotation just given, Colonel Totten remarks:

"It is necessary to observe, in the first place, that the relation of fortifications to the navy in a defensive system is that of a sheltering, succoring power, while the relation of the latter to the former is that of an active and powerful auxiliary; and that the latter ceases to be efficient as a member of the system the moment it becomes passive, and should in no case (we allude to the navy proper) be relied on as a substitute for fortifications. This position may be easily established.

"If our navy be inferior to that of the enemy, it can afford, of course, unaided by fortifications, but a feeble resistance, single ships being assailed by whole fleets; if it be equal, or superior, having numerous points along an extended frontier to protect, and being unable to concentrate, because ignorant of the selected point of attack, every point must be simultaneously guarded: our separate squadrons may therefore be captured in detail by the concentrated fleet of the attacking power. If we attempt to concentrate under an idea that a favorite object of the enemy is foreseen, he will not fail to push his forces upon the places thus left without protection. This mode of defence is liable to the further objections of being exposed to fatal disasters, although not engaged with an enemy, and of leaving the issue of conflict often to be determined by accident, in spite of all the efforts of courage and skill. If it were attempted to improve upon this mode by adding temporary batteries and field works, it would be found that, besides being weak and inadequate from their nature, the most suitable positions for these works must often be neglected, under a necessary condition of the plan, that the ships themselves be defended; otherwise, they must either take no part in the contest, or be destroyed by the superior adversary."

It is hardly to be expected that a system affording so much room for discussion, and by its importance inviting it, should, especially in this country, escape adverse judgement. Military and naval men, congressmen, and even cabinet officers, have assailed it, called in question the principles on which it is based, or denied the judiciousness of their application. The forms and sources of assault have been varied, but there has been really no great difference in the substance, of which, perhaps, as good an expression as any may be found in these dogmas, forming the pith of a criticism from no less a scource than the Secretary of War, Mr. Cass, approved by the President, General Jackson:

"1st. That for the defence of the coast, the chief reliance should be on the navy;

"2d. That in preference to fortifications, floating batteries should be introduced wherever they can be used;

"3d. That we are not in danger of large expeditions; and, consequently,

"4th. That the system of the board of engineers comprises works which are unnecessarily large for the purposes which they have to fulfil."

Owing to these strictures, the House of Representatives, by resolutions of April 9, 1840, called upon the War Department for a report of a full and connected system of national defence. The duty was committed by the Secretary of War to a board of officers of the army and navy, among whom was Colonel Totten, and by whom the report was drawn up. It was entirely approved by the Secretary of War, Mr. Poinsett, and is universally admitted to be one of the most able and comprehensive expositions of the whole subject of sea-coast defence extant, and a complete refutation of the objections made to our existing system. The discussion of the first and principal proposition—that of defence by the navy—is so interesting and instructive that, though long, I venture to quote it:

"The opinion that the navy is the true defence of the country is so acceptable and popular, and is sustained by such high authority, that it demands a careful examination.

"Before going into this examination, we will premise that by the term 'navy' is here meant, we suppose, line-of-battleships, frigates, smaller sailing vessels, and armed steamships, omitting vessels constructed for local uses merely, such as floating batteries.

"For the purpose of first considering this proposition in its simplest terms, we will begin by supposing the nation to possess but a single seaport, and that this is to be defended by a fleet alone.

By remaining constantly within this port, our fleet would be certain of meeting the enemy, should he assail it. But if inferior to the enemy, there would be no reason to look for a successful defence; and as there would be no escape for the defeated vessels, the presence of the fleet, instead of averting the issue, would only render it the more calamitous.

Should our fleet be equal to the enemy's, the defence might be complete, and it probably would be so. Still, hazard, some of the many mishaps liable to attend contests of this nature, might decide against us; and in that event, the consequences would be even more disastrous than on the preceding supposition. In this case the chances of victory to the two parties would be equal, but the consequences very unequal. It might be the enemy's fate to lose his whole fleet, but he could lose nothing more; while we in a similar attempt would lose not only the whole fleet, but also the object that the fleet was designed to protect.

"If superior to the enemy, the defence of the port would in all respects be complete. But instead of making an attack, the enemy would, in such case, employ himself in cutting up our commerce on the ocean; and nothing could be done to protect this commerce without leaving the port in a condition to be successfully assailed.

"In either of the above cases the fleet might await the enemy in front of the harbor, instead of lying within. But no advantage is apparent from such arrangement, and there should be superadded the risk of being injured by tempests, and thereby being disqualified for the duty of defence, or of being driven off the coast by gales of wind, thus for a time removing all opposition.

"In the same cases also, especially when equal or superior to the enemy, our fleet, depending on having correct and timely notice as to the position and state of preparation of the enemy's forces, might think proper to meet him at the outlet of his own port, or intercept him on his way, instead of awaiting him within or off our own harbor. Here it must be noticed that the enemy, like ourselves, is supposed to possess a single harbor only; but, having protected it by other means, that his navy is disposable for offensive operations. If it were attempted thus to shut him within his own port, he, in any case but that of decided inferiority, would not hesitate to come out and risk a battle; because, if defeated, he could retire under shelter of his defences to refit; and if successful, he could proceed with a small portion of his force—even a single vessel would suffice—to the capture of our port now defenceless, while, with the remainder, he would follow up his advantage over our defeated vessels, not failing to pursue into their harbor should they return thither.

"Actual superiority on our part would keep the enemy from volunteering a battle; but it would be indispensable that the superiority be steadily maintained, and that the superior fleet be constantly present. If driven off by tempests, or absent from any other cause, the blockaded fleet would escape, when it would be necessary for our fleet to fly back to the defence of its own port. Experience abundantly proves, moreover, that it is in vain to attempt to shut a hostile squadron in port for any length of time. It seems, then, that whether we defend by remaining at home, or by shutting the enemy's fleet within his own harbor, actual superiority in vessels is indispensable to the security of our own port.

"With this superiority the defence will be complete, provided our fleet remains within its harbor. But then all the commerce of the country upon the ocean must be left to its fate; and no attempt can be made to react offensively against the foe, unless we can control the chances of finding the enemy's fleet within his port, and the still more uncertain chance of keeping him there; the escape of a single vessel being sufficient to cause the loss of our harbor. Let us next see what will be the state of the question on the supposition of numerous important ports on either side, instead of a single one, relying on our part still exclusively on a navy.

"In order to examine this question, we will suppose our adversary to be fortified in all his harbors, and possessed of available naval means, equal to our own. This is certainly a fair supposition; because what is assumed as regards his harbors is true of all maritime nations, except the United States; and as regards naval means, it is elevating our own strength considerably above its present measure, and above that it is likely to attain for years.

"Being thus relatively situated, the first difference that strikes us is, that the enemy, believing all his ports to be safe without the presence of his vessels, sets himself at once about making our seas and shores the theatre of operations, while we are left without choice in the matter; for if he thinks proper to come, and we are not present, he attains his object without resistance.

"The next difference is, that while the enemy (saving only the opposition of Providence) is certain to fall upon the single point, or the many points he may have selected, there will exist no previous indications of his particular choice, and, consequently, no reason for preparing our defence on one point rather than another; so the chance of not being present and ready on his arrival are directly in proportion to the number of our ports—that is to say, the greater the number of ports, the greater the number of chances that he will meet no opposition whatever.

"Another difference is, that the enemy can choose the mode of warfare as well as the plan of operation, leaving as little option to us in the one case as in the other. It will be necessary for us to act, in the first instance, on the supposition that an assault will be made with his entire fleet; because, should we act otherwise, his coming in that array would involve both fleet and coast in inevitable defeat and ruin. Being in this state of concentration, then, should the enemy have any apprehensions about the result of a general engagement, should he be unwilling to put anything at hazard, or should he, for any other reason, prefer acting by detachments, he can, on approaching the coast, disperse his force into small squadrons and single ships, and make simultaneous attacks on numerous points. These enterprises would be speedily consummated, because, as the single point occupied by our fleet would be avoided, all the detachments would be unopposed; and after a few hours devoted to burning shipping, or public establishments, and taking in spoil, the several expeditions would leave the coast for some convenient rendezvous, whence they might return, either in fleet or in detachments, to visit other portions with the scourge.

"Is it insisted that our fleet might, notwithstanding, be so arranged as to meet these enterprises?

"As it cannot be denied that the enemy may select his point of attack out of the whole extent of coast, where is the prescience that can indicate the spot? And if it cannot be foretold, how is that ubiquity to be imparted that shall always place our fleet in the path of the advancing foe? Suppose we attempt to cover the coast by cruising in front of it, shall we sweep its whole length?—a distance scarcely less than that which the enemy must traverse in passing from his coast to ours. Must the Gulf of Mexico be swept as well as the Atlantic; or shall we give up the Gulf to the enemy? Shall we cover the southern cities, or give them up also? We must unquestionably do one of two things: either relinquish a great extent of coast, confining our cruisers to a small portion only, or include so much that the chances of intercepting an enemy would seem to be out of the question."

The report then goes on to discuss the uses for defensive purposes of gunboats, floating batteries and steam batteries, as distinguished from the navy proper. Admitting their usefulness, and, even in some cases, their necessity, it argues with great force that they are not a substitute for and cannot supersede fortifications, and it sums up its argument concerning naval defence with the following broad propositions, to which it challenges opposition:

"1st. If the sea-coast is to be defended by naval means exclusively, the defensive force at each point deemed worthy of protection must be at least equal *in power* to the attacking force.

"2d. As from the nature of the case there can be no reason for expecting an attack on one of these points rather than on another, and no time for transferring our state of preparation from one to another after an attack has been declared, each of them must have assigned to it the requisite means; and,

"3d. Consequently this system demands a power in the defence as many times greater than that in the attack as there are points to be covered.

"There has been but one practice among nations as to the defence of ports and harbors, and that has been a resort to fortifications. All the experience that history exhibits is on one side only; it is the opposition of forts or other works, comprehended by the term fortification, to attack by vessels, and although history affords some instances wherein this defence has not availed, we see that the resort is still the same. No nation omits covering the exposed points upon her seaboard with fortifications, nor hesitates in confiding in them."

The most important cases of such successful attacks, viz., Copenhagen, Algiers, San Juan de Ulloa, &c., are then described and discussed, to show that the deductions drawn from them are erroneous, or that they are not cases in point, or that the disastrous result has been owing to the neglected condition, imperfect armament, or unskillful and inadequate defence of the forts.

The report, of which I have given some of the main points, may be said to have silenced opposition to our system of fortifications for the next ten years; but, in a form modified by the alleged changes in the condition of the country, increase of population, construction of railroads, &c., it again found expression in a resolution of Congress in 1851; and the Secretary of War, to enable himself to respond, called upon numerous distinguished army and navy officers for an expression of their opinions. The following questions were addressed [illegible] engineers officers, among whom the chief [illegible] Totten:

[illegible] invention and extension of railroads have [illegible] the necessity of fortifications on the sea- [illegible]

[illegible] and to what extent the navigation of the [illegible] and particularly the application of steam to vessels [illegible] improvements in artillery, and other military [illegible] affect this question?

[illegible] vessels of war, steam batteries, ordinary merchant [illegible] and other temporary expedients, can be relied [illegible] for permanent fortifications for the defence of [illegible]

How far the increase of population on the northern frontier [illegible] marine on the northern lakes obviates or dimin- [illegible] of continuing the system of fortifications on these [illegible]

[illegible] Totten's response to these critical interrogations is, as [illegible] him when this great subject has to be dealt with, full [illegible] The following pithy paragraphs exhibit his views, [illegible] of railroads:

[illegible] hostile fleet to lie in front of the city of New York— [illegible] would prevent, if the channels of approach were not [illegible] what way could the 100,000 or 200,000 new men poured [illegible] environs by railroads, although armed with muskets [illegible] aid the half million of people already there? It [illegible] very clear that these additional forces would, like the [illegible] of the city, be utterly powerless in the way of resistance, [illegible] means at their command, and, if resistance were attempted [illegible] would but serve to swell the list of casualties, unless they [illegible] retreat beyond the range of fire. If the enemy's expe- [illegible] were intended, according to the second supposed mode of [illegible] invasion, or occupation for some time, of a portion of the [illegible] then in many places this resource of railroads would be [illegible] because then the duty of defence would fall upon the army [illegible] of the country, and these communications would swell [illegible] numbers.

But of all circumstances of danger to the coast, this chance of an [illegible] by an enemy to land and march any distance into a populous [illegible] is least to be regarded, whether there be or be not such speedy mode of receiving re-enforcements, and our system of fortifications has little to do with any such danger. In preparing against maritime assaults, the security of the points to be covered is considered to be greatly augmented whenever the defence can be so arranged as to oblige an enemy to land at some distance; for the reason that opportunity is thereby allowed, in the only possible way, for the spirit and enterprise of the people to come into play.

"Instead of being designed to prevent a landing upon any part of the coast, as many seem to suppose, and some allege in proof of extravagant views on the part of the system of defence, the system often leaves this landing as an open alternative to the enemy, and aims so to cover the really important and dangerous points as to necessitate a distant landing and a march towards the object through the people. It is because the expedition would easily accomplish its object without landing, and without allowing the population to partake in the defence, that the fortifications are resorted to. For instance, without Fort Delaware, or some other fort low down on Delaware bay, an enemy could place his fleet of steamers in front of Philadelphia by the time his appearance on the coast had been well announced throughout the city. And in spite of all New Jersey, Delaware, and lower Pennsylvania, he could levy his contributions, and burn the navy yard and shipping, and be away, in a few hours. But being obliged, by the fort above mentioned, to land fully forty miles below the city, the resistance to his march may be safely left to the courage and patriotism that will find ample time to array themselves in opposition."

Concerning the application of steam to vessels of war he says:

"The application of steam to vessels of war acts upon the question of seacoast defence both beneficially and injuriously. It acts injuriously in several ways; but chiefly, first, by the suddenness and surprise with which vessels may fall upon their object, and pass from one object to another, in spite of distance, climate, and season; and, secondly, by their ability to navigate shallow waters.

"The first property, by which squadrons may run into our harbors, outstripping all warnings of their approach, affords no chance for impromptu preparations; accordingly, whatever our preparations are to be, they should precede the war. It seems past all belief that a nation having in commission—as France and England always have—a large number of war steamers, ready for distant service in twenty-four hours, receiving their orders by telegraph, capable of uniting in squadrons, and in two or three days at most speeding on their several paths to fall upon undefended ports—it is not to be expected, I say, that they should delay such enterprises until temporary resorts could be got ready to receive them. And yet there are those who insist that we should leave defensive measures to a state of war—that we should let the day supply the need!

"Inadequate as all such measures must prove, there would not be time to arrange even these. By the second property, due to their light draught of water, these vessels will oblige the defence to be extended in some form to passages or channels or shoals that were before adequately guarded by their shallowness. The bars at the mouth of the Mississippi formerly excluded all but small vessels-of-war, and the strong current of the river made the ascent of sailing vessels exceedingly uncertain and tedious. Now these bars and currents are impediments no longer; and all the armed steamers of Great Britain and France might be formed in array in face of the city of New Orleans before a rumor of their approach had been heard.

"Had the English expedition of 1814, attended by a squadron of armed steamers, arrived at the mouth of the Mississippi, a few transports might have been taken in tow, and in a few hours the whole army would have been before the city. Or twelve or fifteen such steamers could have carried the whole army up in half a day, without the delay of transports. Will it be contended that the attack in that form would have been repulsed with the means then in General Jackson's hands? Would the landing, or even the presence on board these steamships, of the British troops have been necessary to burn the city or put it under contribution? Is there anything now, but the existence of forts on the river, to prevent the success of such an attack by fifteen or twenty steamers of war, allured there by the vastly increase magnitude of the spoil?"*

While the enemy's means of attack are thus enhanced by the use of war steamers, General Totten contended that they cannot be relied upon, as a subsitute for fortifications, for defence.

"I do not assert," he says, "that armed vessels would not be useful in coast defence. Such an idea would be absurd. I shall even have occasion to show a necessity for this kind of force, in certain exceptional cases. It is the general proposition, viz., that armed vessels,

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*The experience of the rebellion has proved the truth of General Totten's words. The moment the *forts* were passed, the city of New Orleans was, notwithstanding the land forces under Lovell, at Commodore Farragut's mercy. I have alluded to elsewhere in the failure of the forts.

and not fortifications, are the proper defences for our vulnerable points —a proposition the more dangerous, because seemingly in such accordance with the well-tried prowess and heroic achievements of the navy, that we have now to controvert.

"Boston, New York, Philadelphia, Baltimore, Charleston, and New Orleans are, we will suppose, to be guarded, not by forts, but by these vessels, on the occurrence of a war with a nation possessing large naval means. We know that it is no effort for such nations to despatch a fleet of twenty line-of-battleships and frigates, or an equal number of war steamers, or even the combined mass—both fleets in one.

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"What, then, shall we do at the above-named ports severally? Each is justly felt to be an object worthy of an enemy's efforts, and each would be culpable in sending elsewhere any part of the force required for its own defence. Each, therefore, maintains a naval force equal, at least, to that the enemy is judged to be able to send promptly against it. Omitting any provision for other places scarcely less important, what is the result? It is, that we maintain within the harbors of, or at the entrance to, these places, chained down to this passive defence, a force at least six times as large as that of the enemy.

"He does not hesitate to leave his port, because it will be protected in his absence by its fortifications, which also afford him a sure refuge on his return. He sails about the ocean, depredating upon our commerce with his privateers and small cruisers, putting our small places to ransom, and in other ways following up appropriate duties; all which is accomplished without risk, because our fleet, although of enormous magnitude, must cling to ports which have no other defence than that afforded by their presence. They cannot combine against him singly, for they cannot know where he is; and must not, moreover, abandon the object which they were expressly provided to guard.

"It would really seem that there could not be a more impolitic, inefficient, and dangerous system, as there could not certainly be a more expensive one."

I have thus extensively quoted from the reports of General Totten, because they are themselves the best expressions of the life labors and services of the subject of our memoir, and because I think they treat of matters which should be, in an eminent degree, interesting to the members of this National Academy, and which, moreover, should [illegible].

To preserve the continuity of my subject, I have followed these reports down to a late date. It is necessary now to revert to an earlier period. It has already been observed that, as soon as the original board of engineers had sufficiently matured the general system of defence, and completed plans for the works first required, its members applied themselves to the duty of construction. In 1828 General (then Colonel) Totten took charge of the construction of Fort Adams, Newport harbor, and continued on this duty, making his residence in the town of Newport, until December, 1838, the date of his appointment as chief of the corps of engineers. This work, the second in magnitude of the fortifications of the United States, is one of the best monuments of his genius as a military engineer. From its peculiar relations to the land defence, it called for the application of most of those rules of the art and many of those special arrangements which form the themes of treatises upon "fortification," and which, generally, have but a very limited application to works of harbor defence. In these respects it has no parallel with us; and in the treatment of the case and happy adaptation of means to the end, Colonel Totten exhibited a mastery of all the details of the art, which proves his technical skill and minute knowledge to be fully equal to the power of broad generalization I have already endeavored to illustrate. But Colonel Totten found here yet another field for professional usefulness—another tract to explore. The art of the civil engineer (I use the phrase in its application to mere *construction*, whether it be of a military or civil work) was yet in its infancy in this country. Our resources in building materials were almost unknown, their qualities and adaptabilities to different purposes of construction undeveloped. Thus far the matter had excited little attention; the building material, whether brick or stone, lime or timber, nearest at hand was indiscriminately used, and its aggregation left much to the skill of the mechanics. In commencing constructions on so great a scale, it was of the first importance that the work should be both durable and economical—a result only to be attained by the most careful selection of materials, and the most skilful manipulation. Besides, our forts called for arrangements unknown in other branches of building—arrangements for which the execution and the most suitable materials had to be studied out *ab initio*, since on many of these points there were neither experience nor extant rules to guide.

In the years 1830 and 1831 a series of experiments was instituted by Colonel Totten at Fort Adams, on the expansion and contraction of building stone by natural changes of temperature, and the effects of these variations on the cements employed to secure the joints of stone copings. An account of them was prepared under his direction by Lieutenant (now Professor) W. H. C. Bartlett, a member of this Academy, and published in the American Journal of Science for July, 1832. The methods employed were at once simple and ingenious, and the result was such as to leave no doubt that in this climate the joints of copings formed of stone of four or five feet in length will always be insecure, no matter what description of cement may be employed to close them.

This result is one of great practical importance. Previously to the experimental examination of the subject by Colonel Totten, the walls of our most expensive works of masonry were protected by copings cemented at their joints; and while the failure of the cement was constantly noticed, the cause of the failure was not understood. The experiments showed that the changes of longitudinal dimensions of granite coping-stones, five feet only in length, under the extreme temperatures to which they were exposed at Newport, would be sufficient to pulverize the hardest cement between them, or to leave cracks in it thicker than common pasteboard. With marble as a material, these destructive effects are considerably increased, and with sandstone, nearly doubled.

About the same time Colonel Totten caused some experiments to be made to ascertain the relative stiffness and strength of the following kinds of timber, viz: White pine, (*Pinus strobus,*) Spruce, (*Abies nigra,*) and southern pine, (*Pinus australus,*) also called long-leaved pine.

These experiments, made by his assistant, Lieutenant T. S. Brown, of the corps of engineers, were published in the American Journal of Science and Art, and afterwards, having been revised by the author, in the Journal of the Franklin Institute, a note being added, the calculations extended, and practical inferences drawn therefrom. This memoir and additions are found in vol. vii, new series, Journal of the Franklin Institute, 1831. Lieutenant Brown's account concludes with the following remarks:

"In Tredgold's Carpentry, and other similar works, may be found the constant numbers (a) and (c) for nearly all the kinds of wood useful in the arts; but besides that the numbers are in many instances calculated from insufficient experiments, most of the specimens used in the trials were of European growth, and of course the results obtained are inapplicable to American timber, though bearing the same name. It is much to be desired that numerous and accurate experiments be made in this country by those having the requisite zeal and opportunities; our architects will then know with certainty the qualities of the different kinds of woods they are using, and instead of working at hazard and in the dark, as they now too often do, they will be guided by the sure light of practical science to certain and definite results. If these experiments contribute ever so little to the attainment of so important a result, the object of their publication will be fully accomplished."

A subject of such vital importance in the art of construction as the composition of mortars could not fail to invite, or rather compel, the researches of Colonel Totten. No species of masonry is subject to such severe deteriorating influences as the walls and arches of fortifications, especially in our climate; so severe, indeed, that they almost drive the engineer to despair. Next only to the importance of having the building stones or bricks of a suitable character, is that of uniting them by a strong and durable mortar. Few persons whose attention has not been called to the subject conceive its magnitude, the variety of materials it embraces, and the laborious investigations to which it has given rise. Colonel Totten commenced his researches at an early date, and continued them actively during the whole period of his connection with Fort Adams.

His work on "Hydraulic and Common Mortars" was published in 1838 by the Franklin Institute of Philadelphia. It contains, besides original experiments and observations on mortars, hydraulic cements and concretes, translations of essays by Treussart, Pitot, and Courtois, the best French writers on the same subject, and constitutes to this day an authority relied on by American engineers. Colonel Totten's experiments extend over the period from 1825 to 1838; they are especially valuable for the variety of limes and cements, and the tests of different modes of slacking the lime, mixing the mortars, and preparing the cements and concretes. The mortars were tested, after periods ranging from five months to four years and five months, for tenacity, by the force required to separate two bricks joined together by means of them, and for hardness by the weight which they would support, applied over a small circular area. The experiments on concretes or factitious stones are equally comprehensive, being directed to the composition and consistency of the cement, whether best used as a stiff mortar or a semi-fluid grout; to the effect of additions of common lime and sand or rounded pebbles and gravel, and to ascertaining the proportion of each that would be used to the best advantage. The results developed by these investigations are of the greatest value, and having been applied in the construction of the fort, have now had the test of many years experience.

It would be almost impossible to enumerate the various objects of Colonel Totten's researches while at Newport. There is scarce a subject connected with the art or science of the engineer, civil or military, which did not engage his attention, and of which he has not left some record. The thickness of sustaining walls, the thrust of arches, among the more important, and the composition of stuccoes, of paints, lackers, washes for stone or brick work, among the less so, may here be mentioned.

Perhaps no period of his life is so interesting and so affectionately remembered by his professional associates. Indeed, a large proportion of the young officers of the corps of those days passed a portion of their time under his command, and accquired their first professional experience in the performance of duties under his eye and direction. The disposition to cultivate science, physical and natural, led him to original researches, while his influence stimulated and led to improvement the educated young men who from time to time came into his military family. Fond of exercise, bodily and mental, he sought in natural history, as in geology, mineralogy, and conchology, objects for the long walks and drives conducive to health, while the arrangement of the specimens, their care and classification, and the study of the habits of the animals which occupied the shells, gave scope to his wonderful powers of observation. Instead of finding his young officers a trouble, he was fond of their companionship, suggesting modes and objects of experiment, and encouraging them to do so likewise, thus cultivating originality of thought. His laboratory was at their service, and his companionship and example at their disposal. After a day's labor he retired to this laboratory, glad to have with him such of the young companions of the day as desired to join him. The honored president of this Academy can recollect, year after year, the computations, under Colonel Totten's direction, of the thickness of revetments, the analysis of minerals collected in the field, classifications of shells gathered in days' walks on the seashore, discussions of the curious structure of geological specimens in the neighborhood of Newport, and of the curious mineralogical specimens of the upper portion of Rhode Island, which he encouraged them to find. So upon the fort itself, the various researches which I have described were marked out for successive experimenting, with a generosity to his assistants which almost persuaded them that they were original with them. The determination of the measures used in laying out the fort, and the practical apparatus employed in the measurements, received his careful study. The practical character of these works impressed themselves upon the minds of the young officers, and furnished the fitting completment to the theoretical training received at West Point.

Not least pleasant among the memories of this period of Colonel Totten's life, to those who had the good fortune to be associated with him, is the recollection of the social enjoyments of his house. Married in 1816 to Catlyna Pearson, of Albany, he was surrounded by a young family, among whom his happiest moments were spent, and to whom he was everything that such a relation can imply. None could be happier in his social intercourse. Genial and eminently hospitable, he cultivated as a duty those smaller amenities of society by which the cares of life are lightened and its joys augmented. His house was the home of his friends, and was seldom without some one of them. Though dignified and courteously reserved in his intercourse with the external world, few more highly enjoyed real humor, or could with more true *bonhommie* give themselves up to the gayety of the moment. In his relations to his young officers he was kind and affable, encouraging freedom of expression, and inviting inquiry in everything that related to professional matters, while there was always that in his manner which inspired the most profound respect and forbade undue levity of conduct in his presence.

Before quitting the scene of so important a portion of Colonel Totten's official labors, it is proper to remark that, in addition to the duties of his particular charge, he, as a member and for the last six years president of the board of engineers, was engaged in the planning of the new works for which Congress from time to time made the necessary appropriations.* To this duty he usually devoted

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*By the Regulations, the local engineer officer, upon whom the construction of the proposed work was to devolve, was *ex officio* a member of the board. This brought together during the winter months engineer officers from various parts of the country —from the shores of the Gulf, from the seaboard of North and South Carolina and Georgia, as well as from nearer points, and added not a little to the charm of the professional and social life of the young engineer officers at Newport.

the winter months, during which all construction on Fort Adams was suspended. In the execution of his designs he was usually assisted by young officers of the corps, who found therein a practical application of the theoretical knowledge acquired at West Point instructive and useful.

The works of harbor improvement on the seaboard and on the lakes were likewise under the control and direction of the Engineer Bureau; and Colonel Totten, though not directly engaged therein, was not infrequently called on to inspect and advise concerning them. Most of these, and especially those of the lake shores, afforded curious and interesting problems in this branch of civil engineering, and his reports and notes on these subjects, yet extant, are additional proofs of the wide range of his professional knowledge and of his powers of accurate observation and of skilful deduction from the phenomena of nature.

Colonel Totten was appointed colonel of the corps of engineers, and Chief Engineer, December 7, 1838. At this time the construction of Fort Adams was so far advanced towards completion as to need no longer his personal supervision, and the city of Washington became thenceforth his home and the seat of his official duties. Identified, as we have seen, with the origin and growth of the great system of sea-coast defence of the United States, it was eminently proper that he should become the head of that bureau of the War Department to which its execution was committed, and no one could be more eminently fitted for that important station.

At the date of his appointment the system of coast defence had been for about twenty years in progress of construction, and during that period most of those ports and harbors of the United States deemed most important to ourselves or most assailable by a naval foe had been, at least, partially fortified. At many such points, indeed, no new work had been as yet constructed, owing to the existence of forts or batteries more or less adequate built before or during the war of 1812. These works, where possible, were absorbed into the new system with some repairs and alterations. Among such points may be mentioned the harbors of Portland, Portsmouth, New London, Philadelphia, Baltimore, and Charleston. New and powerful works had, however, been built or far advanced to completion, for the defence of Boston, Newport, New York, Hampton Roads, the Savannah river, Pensacola, Mobile, and New Orleans. But the strictures on the system, to which we have before made reference, proceeding tion [illegible] authority as the Secretary of War and sanctioned by the President, had not failed to shake the confidence of Congress and of the people. For several years the annual appropriations had been withheld or even made so inadequately that the work had languished and at some points had been wholly suspended. But, however much opposition may grow up in time of profound peace, no sooner is there a probability of seeing a foe at our doors than all eyes are turned to these protecting works, and the most urgent demands are made that our seaport towns shall be speedily put "in a state of defence." Such an impulse was given by the Maine boundary and McLeod questions, soon after the advent of Colonel Totten to the Chief Engineership. In fulfilling the urgent duty which thus devolved upon him, he did not content himself with the mere issuing of orders from his office at Washington. He made it his business to inspect personally the works, and in less than two years, besides the enormous office labor he found necessary to attend to on the first assumption of charge of the bureau, he had visited every fort and battery on the sea-coast of the United States. His inspections were not superficial and hasty; they were most thorough and searching. His investigations embraced, at the same time, the general scope and purpose of the work, its adaptability to its great objects, and the minutest detail in its construction. It was now that the country derived the full benefit of his indefatigable researches while at Newport.

I have already alluded to the lack of knowledge and experience in this country of the art of construction, especially in its applications to the peculiarites of fortification. To supply this lack was a great end of Colonel Totten's labors at Fort Adams. At few other points did the locality or circumstances of the construction render practicable such researches. This remark will apply particularly to the works on the Gulf of Mexico. The regions bordering the Gulf were, at the close of the war of 1812, but recent acquisitions to the territory of the United States. Sparsely populated and isolated from the rest of the Union as (before the application of steam to the navigation of the Mississippi) they were, they would be defended, if defended at all, only by the aid of fortifications. The fact that New Orleans had been almost wrenched from our grasp, and the impression then everywhere felt that if it had been captured it would not have been relinquished, stimulated the government to secure the possession of this important place and of other strategic points on the Gulf by immediate fortification. Accordingly, designs for works—mostly prepard by General Bernard—were among the first labors of the board of engineers, and the forts on the river and lake approaches to New Orleans, at the entrances to Mobile bay and Pensacola harbor, were almost simultaneously commenced. Around New Orleans especially the engineers had to contend with formidable difficulties. The deadly climate, the treacherous soil, on which no art could build a structure so massive as a fortification that should not sink one or more feet, warping and dislocating the walls and arches, the difficulties of procuring the services of mechanics and laborers, the want of building materials, &c., all combined to make construction exceedingly difficult, to forbid any of its nicities, and to hinder all research or experiment. Some of these works had been entirely finished at the period we have arrived at, others nearly so, and left to "settle" before the weight of the earthen parapets was added.

Considering all these unfavorable circumstances, these works had been built in a manner creditable to the energy and skill of the engineers; but a few years' neglect, aided by a damp and tropical climate, had given many of them an appearance which, to the superficial observer, promised anything but efficiency. Indeed, it was a popular belief in New Orleans at this time that Fort Jackson, on the Mississippi, had sunk so much that its guns could not be brought to bear on the river—a belief doubtless due to the unnecessary highness of the levees by which it had been surrounded to protect its site from inundation, and to the rapid growth of vegetation on and about the fort. Such was the condition of this work when Colonel Totten first visited it in 1841, and the author of this paper, who had but recently taken charge of it, has yet a vivid recollection of the thorough inspections of this and other works, the tedious voyages in open boats through the intricate "bayou" navigation about New Orleans, in company with his chief, as well as the copious and most minute instructions which he received. Destitute of American experience on such points, the designer had followed European precedents, or the constructing engineer had been left to his own devices as to much that relates to the interior arrangements. The wood-work of magazines, inadequately ventilated, had rotted and fallen in ruins; the covering of the bomb-proof casemates, imperfectly understood, had failed to exclude water, which percolated through the piers and arches, or gathered in muddy pools on the floors. The work to be done to bring the forts to speedy efficiency was vast; embrasures and floors of casemates were to be raised to compensate the settlement the work had undergone; earth to be removed from the arches, in order to repair or renew the roofing; magazines and quarters to be refitted, and all this before a gun could be mounted in a proper manner. On all these points Colonel Totten was rich in the experience of his long researches, and ready at once to give the proper directions. Following his detailed instructions, the works speedily reached such a condition of efficiency as to permit the mounting and service of their guns.*

What the writer here relates from his own experience at New Orleans serves but to illustrate the indefatigable labors and personal agency of Colonel Totten at this period, along the whole seaboard of the United States, in bringing all its ports and harbors into a defensible condition. Nor should I confine these attributes to any particular period. During the whole time of his chief engineership he continued the same laborious supervision. Generally once in about every two years he inspected every fort of the United States, and scarcely was the local engineer officer more thoroughly familiar with each detail of his own particular works than was the Chief Engineer with those of all under charge of the Engineer Bureau. Besides attending to the routine duties of his office at Washington, he found time to design plans for new works, as well as for alterations or enlargement of old ones. An admirable draughtsman, executing his work with a delicacy and finish that defied competition on the part of his subordinates, he would be usually found, if visited at his office, engaged at his drawing table. Indeed, if he had a fault as Chief Engineer, it was the habit of doing everything himself. It was contemplated by the Regulations that all plans of fortifications should be made by a board of engineers, and General Totten, in one of his reports, alludes to the fact that this has *not* always been the case, in these words: "In rare cases it has happened that plans have been made under the particular direction of the Chief Engineer, owing to the difficulty, at moments, of drawing the widely dispersed members of the board from their individual trusts." It may be said, too, in justice to him, that when he assumed control of the bureau, it was almost indispensable to take much upon himself, in the direction of the repairs and prosecution of many of the works, owing to the great pressure thrown upon the corps by the circumstances of the period, and the want of a sufficient number of experienced officers.

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*When Forts Jackson and Philip, on the Mississippi, were attacked by the fleets of Commanders Farragut and Porter, they were not provided with the armaments intended for them, and the garrisons were demoralized by a long bombardment. It is not in place to discuss this subject here.

The excitement produced by the anticipation of war with England was followed by an actual war with a weak neighbor, a war inaugurated by the same influences which, in a more potent form, produced the rebellion, or rather of which the rebellion was but the legitimate and natural sequel. Called on by General Scott, who reposed in his professional skill the most unbounded confidence, Colonel Totten assumed, in 1847, the immediate control of the engineering operations of the army destined to invade the Mexican capital, directing in this capacity the siege of Vera Cruz. For his successful services he was breveted a brigadier general, March 29, 1847, "for gallant and meritorious conduct at the siege of Vera Cruz." Having thus successfully accomplished the special task for which he had been selected, he left the army and resumed his station at Washington.

In addition to the onerous duties of his office, involving, besides the labors described, the inspectorship and supervision of the Military Academy, his position and high reputation subjected him to calls for incidental labors by the government, by the States, or by municipal bodies. A few months prior to his appointment as Chief Engineer, 1838, he was, at the invitation of the Secretary of the Navy, ordered to visit the navy yard at Pensacola, and to prepare plans for dry docks, wharves, sea-walls, and other improvements. Save a wretched failure in the shape of a wharf, the place—a navy yard in name—had been, up to this period, destitute of everything that characterizes such an establishment, except an imposing row of officers quarters, and some few storehouses. A board of naval officers' had been convened two years previously to consider the wants of the yard, and had recommended an extensive system of improvements, involving, among other things, no less than four dry-docks. Such constructions, reaching thirty or more feet below the level of low water in the loose sand of the bay shores, were difficult, demanding all the resources of the engineer, and it was on account of General Totten's eminent abilities and high authority in such matters that the Navy Department had recourse to his services. He made a report on the manner of construction, with plans which, if I mistake not, have been a guide in the subsequent operations. Unfortunately, to this day no permanent dry-d[illegible]s, a floating wooden one having, through some work had undergone; earth to be removed from the arches, in order to repair or renew the roofing; magazines and quarters to be refitted, and all this before a gun could be mounted in a proper manner. On all these points Colonel Totten was rich in the experience of his long researches, and ready at once to give the proper directions. Following his detailed instructions, the works speedily reached such a condition of efficiency as to permit the mounting and service of their guns.*

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The legislature of the State of New York having, March 30, 1855, passed "An act for the appointment of a commission for the preservation of the harbor of New York from encroachments, and to prevent obstructions to the necessary navigation thereof," the commission so appointed invited and obtained the co-operation, as an "advisory council," of General Totten, Professor Bache, and Commander Davis, United States navy. The nature of the services thus rendered is best understood by reference to the reports of the commissioners themselves:

"The distinguished reputation of General Totten, Professor Bache, and Commander Davis for scientific attainments, their diversified experience in the construction of hydraulic works, and long observation of the influence of tidal currents in the formation and removal of shoals, indicated them as the best qualified to assist the commissioners in the discharge of their duties, while their high personal character precluded the possibility of their advice being affected by other than the single purpose of arriving at a just decision on the questions submitted to them." And again, after a particular allusion to the services of Professor Bache: "It is the gratifying duty of the commissioners to present to the notice of the legislature the important services which have been gratuitously rendered to the State by General Joseph G. Totten, chief engineer of the United States army, and Commander Charles H. Davis, of the United States navy, who, with Professor Bache, formed the advisory council of the commissioners. Animated by the single desire of preserving the port of New York in all its usefulness, they brought to the consideration of the subjects referred to them the diversified experience of many years spent in the examination and improvement of harbors. The several reports they have made on the exterior lines, on the improvement of Hell Gate, and on the preservation of Gowanus bay, are profound dissertations on the forces and actions of currents, and, while they evince, in some degree, the extent of the labors of those gentlemen, they demonstrate how just is the public estimate of their scientific attainments."

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*The "questionable shape" and suspicious object of this novel craft, set afloat and towed out into the bay by the rebels in 1861, caused anxious surmises on the part of Colonel Brown and the gallant garrison of Fort Pickens, reminding us of the famous "Battle of the Kegs" of the Revolution. The probable object was to sink it in the channel to prevent the entrance of our gunboats. But Colonel Brown's interference prevented the accomplishment of the design. It was abandoned by the rebels, and set fire to by Colonel Brown's orders.

Following the example of New York, Massachusetts soon organized a similar commission for the port and harbor of Boston, on which the same gentlemen were invited to serve, receiving similar testimonials of the high value of their services.

Of the many scientific men of the country who were associated with him in such duties, (of whom most usually was our eminent president,) none exhibited greater zeal and assiduity, few took a more prominent and useful part. The resolutions of the Light-house Board, on the occasion of his decease, which are appended to this memoir, would be, with slight modifications, applicable in reference to all his connections of a similar nature. Inflexible in his integrity, uncompromising in his notions of duty, and watchful to the highest degree for all the interest of the government in all that concerned his charge, it is not strange that the shameless Floyd soon found him an obstacle to his peculiar operations. He was virtually banished from his office, or at least relieved from its duties, which he did not resume until Floyd left the War Department. He took this opportunity—perhaps the very first and only release during his lifetime from the unceasing demand of duty—to visit Europe in company with Mrs. Totten, traveling through France, Italy, Germany, and England. Endowed with those keen perceptions and that harmonious adjustment of faculties which render the mind susceptible to the beautiful, whether in nature or art, he was, in the true sense of the term, an artist. For music, for painting, for sculpture, he had a high relish and a most accurate and discriminating judgement.

By such a one the treasures of art and antiquity of Europe can only be adequately appreciated and enjoyed, as we know they were appreciated and enjoyed by General Totten. He did not fail, however, to take the opportunity to examine, as far as he was able, the fortifications of Europe, of the character and peculiarities of which, however, he had little to learn. On his return he was sent by Floyd to the Pacific coast, with directions to inspect the fortifications in construction, and to report on the defensive requirements of that region. This duty and the report thereon he executed in his usual thorough and exhaustive manner. It furnished him with the opportunity to acquire the same personal knowledge of all that concerned the seaboard defence of our newly acquired territories on the Pacific which he already possessed, beyond any other man, in reference to the Atlantic and Gulf coasts.

In the year 1851 General Totten inaugurated, and continued through the years 1852, 1853, 1854, and 1855, a series of experiments at West Point "on the effects of firing with heavy ordnance from casemate embrasures," and also "on the effects of firing against the same embrasures with various kinds of missles." It will be interesting and conducive to a better understanding of the objects and results of these experiments to say a few words as to the origin and meaning of the term "casemate," and to give an account of General Totten's previous labors in connection with the "casemate embrasure." The word is from the Spanish *casa-mata*, (a compound, most likely, of *casa*, house, and *matar*, to kill ; though it is said also to mean a low or hidden house; but the etymology is not settled,) and seems to have been used to signify a countermine as well as a concealed place, arranged in connection with a fortification, for containing and using a piece of artillery. According to Bardin* it appears to have been applied to the double or triple tier of uncovered gun platforms used by the early Italian and German engineers for flanking the ditch, as well as to valued galleries along the scarp wall. The term finally came to mean, in fortification, any vaulted room under the earthwork of the rampart or glacis, whether intended for service of guns, or for quarters of troops, or for containing stores. A ***gun casemate*** is such a vault abutting against the scarp or countescarp wall through which an "embrasure" is pierced to permit the discharge of the gun; and in the naval service the term has been adopted to signify the part of an iron-clad vessel containing the guns, and which is, for that reason, especially protected by the iron plating. Hence the essential notion of the word seems to involve one or more of the attributes of concealment, shelter, and destructive purpose.

The use of the casemate, in some of its forms, for flanking purposes goes back to Albert Durer and San Micheli, in the early part of the sixteenth century, and it was resorted to by Vauban in his second and third systems, of which the tower-bastions are casemated throughout. But it was reserved for the Marquis de Montalembert, in the latter part of the eighteenth century, to give it an extraordinary developement, and to make the casemate the essential element of a system of fortification. This "most intrepid of authors upon fortification'' (as he is styled by Chasseloup) boldly attempted to apply to his art the same principles by which Napoleon won his victories—the concentration of superior forces upon the decisive points. In his projects we find, upon all parts where there must be a decisive contest of artillery, an extraordinary concentration of guns, amounting in some cases to ten times those of the attacking batteries, the construction of which it is intended to prevent, or which shall be promptly over-powered, if constructed. This concentration he effected, and could only effect, by the use of casemates, upon which, numerous and well constructed, he bases all the strength of his fortifications.

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*Dictionnaire de l'Armé de Terre, &c.

No author on this art has displayed greater genius or a greater affluence of resources, and no author has given occasion for so much acrimonious discussion. Rejected by the French, the principles of Montalembert have been made the basis of the modern German, or ''Polygonal,'' system.

For sea-coast fortification the casemates of Montalembert had a singular applicability, and he has the merit, at least, of being the first writer who has seen in this branch of the art a subject of particular treatment, and who had given special designs for forts and batteries ''for the defence of ports.''

In no warlike structure was there so great a concentration of artillery as in a ship-of-war, such as it was fifty or even twenty years ago. And as there is no limit to the number of ships which may be brought to bear upon a shore battery save that of the range of artillery and the area of navigable water, it is easy to see to what overwhelming hostile fire such a work may be subjected. On the other hand, it frequently happens that the site otherwise most advantageous for a battery is low and contracted, rendering any accumulation of guns impracticable, if mounted on an ordinary rampart, and exposing the unprotected gunners to the fire of the sharpshooters with which the enemy's topmasts are filled.*

It is no small merit of Montalembert to have devised a method of mounting guns which should meet this case. Notwithstanding that the French corps of engineers rejected the system in its intended application, and disclaimed, as an engineer, its author, it nevertheless constructed, in 1786, for the defence of the roadstead and harbor of

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*The topmasts of many of the vessels of Commodore Farragut's fleet in the attack on Forts Jackson and St. Philip contained boat-*howitzers*, destined to fire canister at the gunners of the low batteries of those works.

Cherbourg, forts which are in reality almost copied from his designs.[*] Following the example of the French, other European nations have adopted, for the defence of their seaports, works of the same character, of which the forts of Cronstadt and Sebastopol, once made familiar to us, in their outward appearance, by the pictorials, are recent specimens; and, as we have already seen, Colonel Williams introduced them into our country in 1807, by the construction of Castles Williams and Clinton, and Fort Gansevoort, New York harbor.

An objection urged against casemates, and a grave one, since it is aimed at one of their most important attributes, is that the embrasures of masonry are dangerous to the gunners, from their outward flaring surfaces reflecting into the interior the enemy's missiles. Montalembert was well aware of this objection, calling the embrasure, in its ordinary form, a "murderous funnel," (*entonnoir meurtrière,*) and his sagacity did not fail to prescribe the best remedy by rules intended to reduce to a minimum the external opening. He directed that the throat should be no larger than necessary to receive the muzzle of the gun and to endure the shock of its discharge; that it should not be more than two feet from the exterior surface of the wall; that the cheeks should be parallel to the sides of the sector of fire; and to render practicable these arrangements he invented the "*affut á aiguille,*" (carriage with tongue,) which has served as the type of nearly all subsequent casemate gun-carriages. It is strange that, even while adopting the plans of Montalembert, European engineers should have almost wholly overlooked these maxims, and that it was reserved for our own illustrious engineer to make their application, and, in perfecting the casemate and the embrasure, to become a co-worker with Montalembert, by bringing the casemated water-battery to its highest degree of perfection.

I now revert to General Totten's labors in this connection, and in reference thereto I quote from his report to the Secretary of War:

"The first casemated battery was completed in 1808. It has two tiers of guns in casemates and one in barbette. The exterior openings of the lower embrasures are 4′ 8″ by 6 feet, giving an area of 28 square feet; and of the second tier 3′ 8″ by 5 feet, area 18⅓ square feet; the horizontal traverse of the guns being limited to 44 degrees.

[†] The celebrated Carnot, then an officer of French engineers, but who adopted the views of Montalembert, writes to him: "You have wrung from your adversaries the admission that well-constructed casemates are a good thing," &c. (***Zastrow, Histoire de la Fortification.***)

''Within three or four years of the time just mentioned two other casemated batteries were built, each having a single tier of guns in casemates, with exterior openings of 4′ 5″ by 5 feet, area 22 square feet; one with horizontal scope of about 42 degrees, and the other of about 45 degrees.

''In 1815 the author of this report was called on to prepare a project for the defence of an important channel; and, having been convinced, while employed as an assistant in the construction of two of the batteries just mentioned, that the principles and the details by which the embrasures and the dependent casemates had thus far been regulated were erroneous and defective, set about a careful study of the conditions to be fulfilled in providing for the heavy guns of that period mounted on a casemate carriage that had already been approved and adopted. The result was an embrasure having an exterior opening of 4 feet wide by 2′ 6″ high at the outside line of the cheeks, and 3 feet high at the key of the covering arch, the throat being 1′ 10″ wide. This provided for all the depression and elevation of the gun that the carriage permitted, and also for a horizontal scope of full 60 degrees. Covered with a lintel instead of an arch, the height of the exterior opening might be a little less than 3 feet.

''The plan of this embrasure shows that the interior opening is 5′ 6″ wide, and that the plane of the throat is within 2 feet of the outside of the wall, which, just at the embrasure, is 5 feet thick.

''A slight modification fitted this embrasure, when applied to flanking or interior defence, to receive at first a carronade of large calibre, and of later years a howitzer instead. When these latter were liable to be assailed by musketry, the outer cheeks were made *en cremailliere*, (notched,) a long-known device.

''It was with timidity and hesitation that the cheeks of this embrasure were placed so near the track of the ball, when fired from the casemate, with the maximum obliquity, and the results of an early trial with experimental embrasures at Fortress Monroe gave some sanction to the doubt. The first two under trial were built of lime-mortar, and were soon shaken to pieces by the blast of the gun. Another one, however, constructed of bricks laid in cement-mortar, sustained without injury several hundred discharges. These last results have been confirmed wherever there has been practice from our embrasures, which, with immaterial differences, have, since 1815, been constructed in all our casemated batteries according to the preceding description.''

It will be seen from the foregoing quotations how thoroughly General Totten, in adopting the casemated battery, was imbued with the spirit of its illustrious originator. If, as is likely, he was aware of the latter's rules on this subject, he was the first to appreciate their essential importance, and to prove the practicability of their application. It is probable, however, that the close study of the subject, critical observation, and keen sagacity which so distinguished him on all occasions, and which taught him to accept nothing as the best which was susceptitble of improvement, led him to recognize as "murderous funnels" the embrasures of routine—to create anew the rules of Montalembert, and to make, for the first time, a successful application of them. He reduced the throat to nearly an absolute minimum; he placed it at two feet from the outer face of the wall, diminishing the external openings from eighteen, twenty-two, and twenty-eight, down to about ten square feet, while he increased the sector of fire of the gun from forty-five to sixty degrees; thus adding one-third to its field of fire, and consequently to its value.

The embrasures, thus modeled in 1815, remained unchanged until the year 1858, but the casemate continued a subject of study and experiment during most of his life. The perfecting of ventilation, the determination of the dimensions and height of the piers, of the span and rise of the arches, their thickness and manner of covering, so as to obtain perfect drainage and to avoid the injurious effects of frost, &c., were problems of prolonged research and skillful solution, establishing for General Totten the right to be considered the author of the American casemate.

In connection with these researches may be mentioned those also which were directed to the determination of the manner of mounting guns "en barbette."* As the dimensions of sea-coast ordnance increased, more and more elaborate structures became necessary for their mounting and management. The planning and construction of the carriages belonged to the Ordnance Bureau, but it was General Totten's task to adapt the platforms and parapets thereto. None but the engineer or artillerist can thoroughly understand the difficulty and complexity of the problems therein involved. To provide a platform which shall support, without the slighest deflection, the weight, and resist the shock of discharge, while it provides for the training or pointing of the gun—which is so adapted to the paraphet as to allow the maximum horizontal sector of fire, and to afford the most perfect cover to the gunners consistent with allowing all the depression demanded by the circumstances of the case—such are the conditions to be fulfilled, separately, for each calibre of gun. After years of experience, and after our sea-coast ordnance had attained its highest developement prior to the introduction of the rifled gun and fifteen-inch columbiad, General Totten embodied his results in a lithographic sheet exhibiting to the eye of the engineer for every kind of gun and for every probable case the particular solution. This single sheet exhibits strikingly the charactertistics of the author's mind —the profound study which he brought to bear on every subject, the scrupulous accuracy of his determinations, which neglected no appreciable magnitude, and the thoroughness and generality of his solutions.

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*A barbette gun is one which is fired over a parapet.

When the embrasure of 1815 was designed, ships' armaments contained no gun heavier than a twenty-four or thirty-two pounder. As the calibres increased it became a matter of doubt whether the five feet thickness of wall immediately about the embrasure was sufficient. At the same time the progress made in the art of forging large masses of iron had suggested that by its use the funnel form of the mouth might be entirely done away with, and the exterior opening reduced to an absolute minimum. Nothing but *experiment* could lead to sound conclusions, and the experiments referred to on a former page were instituted, the principal objects of which were (in General Totten's own language)—

I. "To ascertain the effects of firing with solid balls, with shells, and with grape and canister, from heavy ordnance at short distances, upon various materials used in the construction of casemate embrasures.

II. "To determine whether these embrasures might have a form that would shut out most of these missiles, and resist for a time the heaviest, without lessening the sector of fire, horizontal and vertical, of the casemate gun.

III. "To determine the degree to which, without injury from the blast of the gun, or lessening its scope of fire, the throat of the embrasure, and also the exterior opening, might be lessened.

IV. "To determine whether all smaller missiles might not be prevented from passing through the throat into the battery; and whether the smoke of the blast might not also be excluded by simple and easily managed shutters."

Targets were constructed representing the wall of a fortification pierced with its embrasures. All varieties of materials were employed in the walls, and every suggested method of constructing the embrasure was tried. General Totten's report shows that the minutest detail of construction was directed by himself, and that he personally superintended the experiments. They were carried on at intervals during four successive years, the results of each year suggesting the object of experiment for the next.

It would be out of place here to follow the report through its detailed accounts of the firings, or even to attempt to sum up the conclusions arrived at, referring as they do to such a variety of subjects; but those concerning the thickness of the scarp-wall and the use of wrought iron may be properly quoted as among the most important:

"The general conclusion from these trials is, that, whether of cement concrete, of bricks, or of hard stones, the portion of the wall at and around each embrasure having the thickness of five feet only should be no larger than is indispensable for the adaptation of the gun and carriage to the embrasure; if restricted to a small area, this thickness will suffice—not otherwise.

"The thickness of five feet will resist a number of these balls, impinging in succession on that space, provided the bond expand promptly above, below, and on each side, into a thickness greater by some two and a half feet or three feet or more. Were the wall no thicker generally than five feet, being reinforced only by piers some fifteen feet apart, it would soon be seriously damaged by battering at short distances."

And in reference to iron it is stated: "First, it may be fairly assumed that a plate eight inches thick of wrought iron of good quality, kept in place by a backing of three feet of strong masonry, will stop a solid ball from an eight inch columbiad fired with ten and a quarter pounds of powder from the distance of two hundred yards. The plate of iron will be deeply indented at the point of impact, the ball carving for itself a smooth bed of the shape and size of one hemisphere, in which it will be found broken into many pieces easily separable, and it will, besides, be somewhat bent generally. The masonry behind will be much jarred, and, unless strongly bonded, be considerably displaced; moreover, unless the thickness of three feet is well tied into thicker masses immediately adjacent on the sides and above and below, the general damage will be severe.

"Second, this plate will be much the stronger for being in a single mass, and not made up of several thinner plates. The continuity effected by bolts and rivets of the made-up plates is broken even by weak assaults, so that afterwards the stronger, instead of a joint opposition, finds only a succession of feeble resistances.

"Third, a thickness of two inches is ample for shutters designated to stop the largest grape-shot. With this thickness they will be neither perforated nor deformed by anything less than cannon balls or shells. These shutters also, for the reason just given, should be made of a single thickness. The firings show the necessity of concealing entirely, even from the smallest iron missile, their hinges and fastenings.

"Fourth, a wrought iron plate of half an inch in thickness is adequate to protect the outer margins and the offsets of embrasures from injury by grape or canister shot."

These facts established, the effect of the form and dimensions of the embrasures in carrying in the smaller missiles was investigated; the recorded results will enable us to appreciate the force of Montalembert's expression, "murderous funnels," as even its author could not do.

"Suppose a hundred-gun ship to be placed within good canister range of a casemated battery of about the ship's length and height, to the fifty guns of the ship's broadside there would be opposed about twenty-four guns in two tiers in the battery. The ship would fire each gun once in three minutes, or ten times in half an hour; the fifty guns would therefore make five hundred discharges within that time.

"With one hundred and fifty-six balls in each thirty-two pound canister, (weighing in all thirty-one and a half pounds,) there would be thrown seventy-eight thousand balls in thirty minutes. Supposing one-half to miss the fort, which, considering the size of the object and the short distance, is a large allowance, there would still remain the number of thirty-nine thousand balls to strike a surface of (say) six thousand square feet—that is,

"On each square foot	6½ balls.
"Or within the exterior opening of one of the embrasures of our second target, of which the area is 8.9 square feet, there would fall	58 balls.
"Within the European embrasure above mentioned, having fifty-four square feet of opening,* there would be received in half an hour	351 balls."

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*Reference is made to the embrasure of a European work built within the last twenty-five years.

And if the ship carried modern eight-inch guns, and fired canister of musket balls, these figures would be, in the three cases, fifty-one, four hundred and fifty-three, and two thousand seven hundred and fifty-four. These theoretical conclusions were verified by the experimental firing with grape and canister, and it is thus seen how greatly superior General Totten's embrasure of 1815, which is but little larger than that of the second target, is to the European one, and how thoroughly he had, at that early day, mastered the subject. He had, indeed, perfected the embrasure so far as it could be done with masonry alone.

But the quantity of small missiles which even that embrasure would receive is dangerously great, and would be much diminished if the funnel-form of the mouth could be done away with, and the throat reduced to an absolute minimum. This could be accomplished only be the use of iron, and the conclusions I have just quoted furnish the data necessary to its successful application.

The throat (still placed two feet back from the outer face of the wall) being formed of iron plates, it became practicable to cut away the flaring surfaces of masonry, so as to present others parallel or perpendicular to the face of the wall, and by this change of form to exclude all missiles not directed within the limits of the throat itself. Still more completely to accomplish the object, wrought-iron shutters of two inches thickness (as determined by the experiments) were applied, by which, except at the moments of aiming and firing, the embrasure was entirely closed.

Such is the history of the casemated battery and casemated embrasure in the United States. We have seen that the perfection to which they have been brought is due to General Totten, and to General Totten alone. Nor is it to the experiments which I have been describing, laborious, skillful, and thorough as they were, that we may solely attribute such results. We must look back to the time when, a first lieutenant of engineers, he saw and aided in the contruction of our first casemated fort, and when he, fully appreciating its merits and recognizing the defects which a disregard and want of appreciation of the illustrious projector's own principles had entailed upon it, set himself to the task of enhancing the one and correcting the other.

The ten years which have elapsed since 1855 have witnessed changes in the character of sea-coast and naval artillery, and an increase in the calibres and weight of their projectiles, which no one at that date would have anticipated; hence some doubt may be enterained whether our casemated masonry works are adequate to contend with iron-clad vessels armed with the modern artillery. This is a question which it remains for experiment or experience to decide. It has, as yet, not been demonstrated that a masonry fort, constructed as our more recent works are, will not, armed with the powerful guns now being introduced, endure the contest quite as long as its iron-clad antagonist can protract it.

In this connection it is due to General Totten to say that he has himself been ever the most strenuous advocate of "big guns," the most urgent instigator of their production. The writer well remembers when, seated with him on the piazza of the officers' quarters at Fort Jackson, our eyes resting on the mighty stream flowing past us, upon the defence of which our thoughts and conversation had been turning, he exclaimed, "We must have a 20-inch gun." The idea was novel to me at that time, and I exhibited some surprise. He went on to say that, thoroughly to prevent the passage or attempted passage of an armed steamship, there must be not only danger but almost a certainty of destruction. "Let us have such guns that (to use his own phrase) 'every shot shall be a bird.' " The invention of armored ships, not then foreseen, has increased the necessity of having such guns as he, on other grounds, so strongly advocated. He expressed the greatest confidence that a gun of the dimensions he named would yet be made and introduced into our batteries, and added the interesting statement that in his earlier days he had found much difficulty in impressing upon the members of boards on which he had served the necessity of having guns in our harbor defences larger than 24-pounders. To the labors and genius of a Rodman we owe the actual invention of the art of constructing fifteen and twenty-inch guns; but without the unceasing stimulus of General Totten's known and urged views, it is doubtful whether Rodman's labors would have been called for or sustained.

The preceeding pages have been mainly devoted to the illustration of our departed associate's career as an officer and as the Chief Engineer of the United States. Before turning our attention to other spheres of his usefulness, it seems fitting to quote from one of his eulogists the following summary of his official characteristics:

"In wielding the influence of his office as Chief Engineer, the prominent traits exhibited by General Totten were strict justice and scrupulous integrity. No sophistry, no blandishments, no arbitrary exercise of superior authority could turn him in the least from his steadfast adherence to his own sense of duty. Avoiding all useless collisions with his official superiors, showing due respect to their station, he never failed to call their attention to any errors committed by them with respect to the department under his charge; nor did he ever leave them any excuse for wilful wrong-doing by remaining silent, even when he knew that his suggestions would not only be ill-received and of no use, but might be visited by the exercise of those petty vexations which official superiors can employ against those under them who thwart their misdoings.

* * * * * * *

"The individual traits of General Totten were strongly marked. Powerfully built, of a constitution of the most vigorous stamp, cool, potent, and persevering, of sound judgement and variety of intellectual capacity, nature seemed to have endowed him for the profession that he had chosen. His attention to the performance of his professional duties amounted to a devotion.

* * * * * * *

"Whilst steadily adhering to what had been well settled by experience, and withstanding the ill-directed efforts of that class of men of whom some are to be found in all bodies, who seize upon every novelty and press it into the service of their own crude notions, he was far from rejecting well-reasoned projects of improvement, and encouraged, as his own immediate works show, every step toward real progress. Although not belonging to the class of mere inventors, he had that invaluable faculty to one holding a position of so great public responsibility, of detecting the fallacies with which this class too frequently deceive themselves as well as others."

In 1863, under the law uniting into one the two corps of engineers and topographical engineers, General Totten was advanced to the full grade of brigadier general. A few days before his death the Senate unanimously confirmed his nomination by the President to be "major general by brevet, for long faithful, and eminent services." Never were such distinction and such commendation more fitly bestowed.

Giving the precedence in order to duties most intimately connected with his profession, I now turn to General Totten's important labors in establishing and maintaining our present light-house system.

The attention of Congress having been called to the pressing necessity for introducing certain reforms, administrative and executive, into the light-house system of the United States, that body, after full discussion of the subject, passed an act (approved March 3, 1851,) stipulating that from and after that date, in all new light-houses and all light-houses requiring illuminating apparatus, the lens or Fresnel system should be adopted.

Another chapter of the same act provided for the appointment of a commission, to be composed of two officers of engineers of the army, and such civil officers of high scientific attainments as might be under the orders or at the disposition of the Treasury Department, and a junior officer of the navy as secretary, whose duty it should be to inquire into the condition of the light-house establishment of the United States, and to make a general detailed report and programme to guide legislation in extending and improving our present system of construction, illumination, inspection, and superintendence.

The board, as constituted by the President, consisted of Commander W. B. Shubrick, General J. G. Totten, Colonel James Kearney, Captain S. F. Dupont, United States navy, Professor A. Dallas Bache, superintendent United States coast survey, and Thornton A. Jenkins, United States navy, as secretary.

Its labors were directed first to demonstrating the evils, irregularities, and abuses which had crept into the light-house service under the management of the Fifth Auditor of the treasury, (the late venerable and highly respected Stephen Pleasonton,) among which were found to be those arising from defective principles of construction, renovation, and repair of light-houses, inadequate protection to sites and badly planned and poorly constructed sea-walls. It may readily be understood how the peculiarly practical mind of General Totten, brought to bear upon these and kindred subjects of inquiry, developed and demonstrated the necessity of at once employing proper scientific systems and plans of construction. His assistance in collecting data was found invaluable, and his lucid, clear mind was equally to be trusted in detecting faults and in devising the remedy.

Without entering into a detailed account of the labors of this board of inquiry, it is sufficient to state that the mass of evidence collected by it was so irresistible in proof of existing errors, that Congress, under date of August 31, 1852, passed an act which created a permanent light-house board, to which was confided all the duties of the establishment. General Totten was appointed to this board, and served as a valued and honored member, with but a short interruption, until his decease. Its early labors were arduous and onerous. A new system was to be founded where before had been none; order should come from chaos, error was to vanish before science, economy to succeed to wastefulness, darkness to give place to light. The task, great as it was, fell upon no shrinking hearts or feeble brains. The work was accomplished; and long before his lamented death General Totten had the satisfaction of witnessing the labors of himself and his associates crowned with full success. The board in its deliberations derived great benefit from his presence and participation, and relied with entire assurance upon the correctness of his judgement upon all subjects concerning which he would express an opinion. He served almost continuously as chairman of the committee of finance, and the decisions of that committee owed not a little of their sound wisdom to the searching scrutiny joined to the generous and liberal views of its chairman. He was also a member of the committee on engineering, in which department his peculiar merit was most conspicuous. The principal works with which his name is associated, and which claim our attention, are the light-houses on Seven-Foot Knoll, near Baltimore, Maryland, and on Minot's Ledge, off Cohasset, Massachusetts.

The former is an iron pile structure standing in some ten feet of water. It was erected at a time when the science of iron pile construction was in its infancy, and was one of the first works of the kind undertaken by the board. Hence it was a matter of deep interest and solicitude. It was successfully completed, and the light-house stands to-day a signal reward for the thought and labor bestowed upon its conception and construction.

The light-house at Minot's Ledge was a work of far greater difficulty, and to its proper location and plan General Totten lent the resources of his great experience and exhaustless knowledge. As his intimate acquaintance with the whole coast of the United States, acquired while acting as a member of the board of engineers, and during his annual inspections as Chief Engineer, enabled him, with the aid of the Coast Survey, to indicate with almost unerring certainity the proper location and character of all new light-houses, so his practical knowledge of construction, in laying the foundation of our sea-coast fortifications and the sea-walls by which the sites of many of them had to be protected, prepared him to grapple with the difficulties of constructing a masonry tower in this exposed situation, and to bring to their solution all the known and tried resources of engineering.

Minot's Ledge is situated about twenty miles southeast of Boston. It is the outer rock of a very dangerous group called the "Cohasset

Rocks,'' lying at the very wayside of navigation to the harbor of Boston. A light-house of iron had been erected here a few years previous to the organization of the Light-house Board, but it was carried away in a fearful storm which swept along the coast of New England on the 16th of April, 1851.

Not only the commercial interests of the country, but humanity demanded that it should be replaced, and Congress promptly made an appropriation for this purpose, stipulating that the tower should be erected on the outer Minot, and confiding its construction to the Topographical Bureau. This bureau, having publicly advertised, received sixteen distinct proposals to erect the proposed structure, but finally recommended, in view of the difficulties to be overcome, and the fearful fate of its predecessor, that it should be located on one of the inner rocks. In accordance with this recommendation, an act of Congress was passed authorizing the Secretary of the Treasury to ''select, instead of the outer Minot's Ledge, any more suitable site.'' Before further action had been taken, the whole subject fell into the hands of the newly created Light-house Board. A joint resolution of Congress was then passed (1854) giving to this board the decision as to the location and the mode of construction.

The question of location being thus widely reopened, a committee of the board was sent to make a personal examination of the locality. General Totten was, of course, a member of this committee, and was not long in making up his mind that the outer and not the inner Minot was the proper site. His arguments on this subject proved conclusive with the board. He urged that if the light were placed on any of the inner rocks the desired object would be but partially accomplished, since in a dense fog or thick snow-storm vessels might approach within a few hundred feet without being able to see it, and thus be lost upon the outer ledge.

When the question of practicability was broached, his professional pride seemed to be roused. He argued that, after what had been done on the coast of England in the erection of the Eddystone light-house a century ago, and more recently of the Bell Rock and Skerryvore lights, it would be a humiliating admission that the requisite science and skill were not found to be in this country to erect a similar structure where, as all admitted, one was so much needed.

He carefully studied the accounts of the construction of the Eddystone, Bell Rock, and Skerryvore light-houses, by Smeaton, Robert Stephenson, and Allan Stephenson, but the fact that the Eddystone was begun at high-water mark, that the ledge of the Bell Rock was extensive, and elevated several feet above low-water, and that the Skerryvore presented still less difficulties, while the surveys show that the outer Minot's ledge was very contracted, and that the proposed structure must commence even below low water, did not deter him from advocating and designing a work for this formidable position more difficult to accomplish than anything which had ever preceded it.

The plans which he prepared were drawn with his usual minuteness of detail. The problem was one peculiarly fascinating to engineers—the uniting into a single mass the several component stones of the structure so that no one can be detached from the rest, that each shall be a bond of connection to those adjacent, that the whole shall be an integral, having a strength ample to defy the most powerful foe to human structure, the fury of the ocean's winds and waves. Though not himself the constructor of the work, yet to have insisted against authoritative adverse opinion on its practicability, to have planned the building and selected the engineer who should rear it, and to have overlooked the work from its commencement to its completion, entitles him, even were this his only work, to recognition among the Smeatons and Stephensons and Brunels, as one of the great engineers of the age.

For the execution, he selected Captain (now Brevet Brigadier General) Barton S. Alexander, of the Corps of Engineers, an officer whose experience, energy, boldness, and self-reliance eminently fitted him for the task. It is for him to recount the history of the work, to give to the world the interesting narrative of difficulties met and overcome, of patience requited and energy triumphant. General Totten watched its progress with unflagging interest, making frequent visits to the superintending engineer, aiding him with his counsels and encouraging him in his difficulties. He lived to enjoy the proud satisfaction of inspecting the finished structure; and when at last from its towering summit flashed o'er the troubled waters the beacon light of safety to the tempest-tossed mariner, he might well exclaim, with the Latin poet, though in a nobler sense and in a less boastful spirit, "Exegi monumentum ære perenius."

General (then Colonel) Totten was named in the act of Congress organizing the Smithsonian Institution in 1846 as one of the Regents to whom the business transactions of that celebrated establishment are instrusted. At an early meeting of the Board of Regents he was appointed one of the Executive Committee, and was continued in these offices by repeated election to the time of his death, a period of nearly eighteen years. He evinced a lively interest in the organization of the Institution, and after a careful study of the will and character of Smithson, gave his preference to the programme prepared by Professor Henry, which was finally adopted. His advocacy of the plan was the more important since he was well acquainted with the scientific character of James Smithson, and had himself, as we shall see in a subsequent statement, been engaged in a line of research similar to one of those pursued by the founder of this Institution.

In the reconstruction of the interior of the main part of the Smithsonian building which had partly been completed in wood, but which had given way, he strongly urged the employment of fire-proof material, to the adoption of which the preservation of the valuable collections of the Institution is indebted. In the discharge of his duty as one of the Executive Committee, he acted with the same conscientious regard to the sacredness of the trust which characterized all his official labors, and critically examined all the accounts, assured himself as to the proper expenditure of the funds, and advised as to the general policy to be pursued. In him the Secretary ever found a firm supporter, a sympathetic friend, and a judicious advisor. Unostentatious, unselfish, and only desiring to advance whatever cause he might be connected with, he gave the most valuable suggestions as if they were of little moment, and in such a way that they might appear to be deductions from what others had said or done, being more anxious that his suggestions should be properly carried out than that they should be accredited to himself.

As a recreation from the more arduous studies of his profession, he devoted in the early part of his life his spare hours to natural history, paying much attention to the mollusca of the northern coast of the United States; and he was perhaps the first, or at least one of the first, to introduce into this country the use of the dredge for the search of these animals, thus not only obtaining many species which would otherwise have escaped attention and getting fresh and unmutilated specimens of species previously known only from dead imperfect shells, but enabling us to learn something of the habits and associations of the animals—information of much greater scientific value than the discovery of a few new species. His observations and studies in conchology were embodied in an article entitled "Descriptions of some shells belonging to the Coast of New England," published in the American Journal of Science and Arts for 1834 and 1835, and Dr. A. A. Gould was largely indebted to him for material employed in his "Invertebrata of Massachusetts," many of the species of shells contained in which were first found to inhabit our coast by General Totten; others were new species discovered by him, though described by Dr. Gould, while some nine or ten specimens were not only discovered but described by him. The descriptions of species and remarks evince his powers of observation and critical acumen, and almost all of the forms described have stood the test of subsequent examination, and the validity of their specific distinction been confirmed, although several of them are among the most common shells of the coast; on account of their small size, they had been previously overlooked or neglected, but their insignificance in size did not diminish their interest in the eyes of one who viewed nature in all her manifestations as worthy of contemplation. One of the most beautiful and almost the smallest of the bivalves of our coast, called by him *Venus gemma*, has since been dedicated to him under the name of *Gemma Tottenii* by Dr. William Stimpson.

General Totten collected principally on the shores of New England, and his explorations with the dredge were almost entirely made in the vicinity of Newport, R. I., and of Provincetown, Mass. A list of the shells of Massachusetts was contributed by him to one of the preliminary reports on the natural history of that State. The principal species described by him are as follows: *Modiola glandula*, (now known as *Mytilus decussatus*,) *Venus gemma*, (*Gemma Tottenii*,) *Solemya borealis*, *Bulla oryza*, *Natica immaculata*, *Turbo minutus*, (*Rissoa minuta*,) *Turitella interrupta*, (*Chemnitzia interrupta*,) *Acteon trifidus*, (*Chemnitzia trifida*,) and *Pasithea nigra*. This last-named species he described from young shells, and afterwards finding the adult shell, which is very different, called it *Cerithium reticulatum*. It has for many years been called *Cerythium Sayi*, but a late author has again credited it to him, under the name of *Bittium nigrum*.

A species of *Succinea* (*S. Totteniana*) was dedicated to General Totten by Mr. Isaac Lea, of Philadelphia.

Conchologists are also indebted to General Totten for the discovery of means for the preservation of the epidermis or periostraca of shells, which is in many species so liable to crack, and this recipe has been received with much approbation by many collectors who have found it to supply a want much felt. The valuable collection of rare shells which he made at this period of his life he presented to the Smithsonian Institution, without the usual condition that it should be preserved seperately, but to be used most advantageously for the advancement of science, to complete the general collection of the museum, or for distribution as duplicates to other establishment.

In the "Annals of the Lyceum of National History of New York" for 1824 (vol. i, pp. 109-114) he published "Notes on some new Supports for Minerals, subject to the Action of the Common Blow-pipe." These researches on the use and power of the blow-pipe appear to have been incited by an article of James Smithson, the subsequent founder of the Smithsonian Institution, and the memoir of Totten commences with a reference to and rehearsal of the experiments of that gentleman, as detailed in a letter to the editor of the Annals of Philosophy. Smithson, it was remarked, had communicated several ingenious modifications of Saussure's process with supports of splinters of sapphire, which process, he observes, "has been scarcely at all employed; owing partly to the excessive difficulty, in general, of making the particles adhere, and in consequence of the almost unpossessed degree of patience required, and of the time consumed by nearly interminable failures." Detailing the processes of Mr. Smithson, three in number, and the success of that gentleman, he adopted a modification of Smithson's third process, having recourse, as a support, to a portion of the mineral itself, which he designed to expose to the action of the flame. "Instead, however, of taking upon the point of platinum wire a very minute portion of the paste made of the powdered mineral," according to Mr. Smithson's method, he formed a paste, by mixing the powder with very thick gum-water, and, rubbing a little of it under the finger, formed a very acute cone, sometimes nearly an inch in length, and generally about a twentieth of an inch in diameter at the base." To the apex of such cones the most minute particles would adhere under the strongest blast of the blow-pipe, and being insulated by the destruction of continuity of the particles of the cone, the flame could be directed upon it with undiminished fevor. Experiments were made on a number of minerals, confirming those of Mr. Smithson, and greatly extending the power of the blow-pipe, and he was thus led to add to the three classes divided in relation to this instrument a fourth, namely, "such as are fusible, *per se*, in microscopical particles."

The attention of the inhabitants near the shores of the great lakes of the north had often been arrested by the sudden disappearance in the spring of the ice on the surface. The lakes would be covered with a continuous sheet of solid ice in the evening, and in the next morning all would have vanished. Wild speculations had been entertained as to the explanation of this phenomenon previous to the investigation of the subject by General Totten, who presented an article on the subject to the American Association for the Advancement of Science at the Springfield meeting in 1859.

From this it appears that his attention had been directed to it forty years before, at Plattsburg, New York. Ice is composed of a congeries of prismatic crystals, whose axes are at right angles to the surface of the mass. "Examinations then and afterwards made of floating fresh-water ice have shown that the natural effect of the advancing year is gradually to transform ice, solid and apparently homogeneous, into an aggregation of these irregular prismatic crystals, standing in vertical juxtaposition, having few surfaces of contact, but touching rather at points and on edges, and kept in place at last merely by want of room to fall asunder. Until this change has somewhat advanced, the cohesive strength of ice of considerable thickness is still adequate to sustain the weight and shock of the travel it had borne during the winter; but becoming less and less coherent by the growing isolation of the prisms, or more and more 'rotten', as the phrase is, though retaining all its thickness, the ice will at last scarcely support a small weight, though bearing upon a large surface, the foot of man easily breaking through, and very slight resistance being made to the point of a cone." The points of contact of the particles being destroyed, each will drop into the position in the water below required by the place of its own centre of gravity—that is to say, it will be upon its side, exposing large surfaces to the action of the warm water. With the ice in such condition, a heavy wind will cause the disruption of the particles, and the speedy disappearance would be the consequence. This remark of General Totten as to the crystallization of ice has since been extended to nearly all substances which, in becoming solid, assume the crystallized form. The axes of the crystals tend to assume a position at right angles to the surface of cooling.

As illustrative of the mind of General Totten, it may be stated that he seldom failed to give valuable hints for the improvement of processes or inventions which were brought before him in the course of the discharge of his numerous official duties. Among these was an instrument for ascertaining the daily amount of evaporation from a given surface by means of the descent of water contained in an inverted graduated tube, the open end of which was immersed in the basin from which the evaporation took place. With a slight correction for variation in barometrical pressure, this instrument gives, with more precision than any other with which we are acquainted, the amount of evaporation.

I have, gentlemen, thus faintly and inadequately sketched the life and services of our departed friend and associate; but, faint and inadequate as my sketch may be, I feel confident that every one will recognize in it the lineaments of a great and true man. Labors so protracted, results so important and varied, it is the destiny of but few to achieve, and for him who achieves them may justly be claimed a high niche in the temple of fame, and the grateful homage of the patriot and of the seeker after truth. One of the oldest of the corporators of this academy, it was permitted him only to contribute his past labors and his shining example. But these are indeed a rich legacy. Proud, indeed, may this youthful institution be that it can enroll among its members the name of Joseph Gilbert Totten; proud, too, may each one whom I now address—each one of its members—be, if he shall achieve but a far less claim to recognition among men of science. To the aged among us—to those who were young with him, and like him have crowned a life of toil by honorable achievements—I need not speak. *They* require no example, and they may feel in contemplating his history an additional assurance that their own works, too, "shall praise them." To the more youthful or to the middle-aged, who have just commenced, or but partially accomplished, the steep ascent which leads to honorable fame, his life is precious in its teachings.

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No. 8.
OCCASIONAL PAPERS,
U.S. ENGINEER SCHOOL OF APPLICATION,
UNITED STATES ARMY.

REPORTS

FIRST BATTALION OF ENGINEERS

AT THE

MANEUVERS AT FORT RILEY, KANS.,

1903.

MAJOR SMITH S. LEACH,
CORPS OF ENGINEERS, COMMANDING.

ENGINEER SCHOOL OF APPLICATION,
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HEADQUARTERS, 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANS.,
November 17, 1903.

THE ADJUTANT GENERAL,
DEPARTMENT OF THE MISSOURI,
Omaha, Nebr.

SIR:

1. I have the honor to submit the following report of the participation of the 1st Battalion of Engineers in the recent maneuvers at Fort Riley, Kansas.

2. Pursuant to the provisions of par. 3, Department S. O. 178, c. s., the Battalion left this post at 8:30 A. M., September 23d, and marched to Fort Riley, arriving there at 1:00 P. M. October 2d. The trip was made in nine marches of approximately equal length. No march was made on Sunday, September 27th, the Battalion remaining in camp at Kilmer on that day. Five days' rations were carried from the post, and five days' were received by rail at Silver Lake. A tool wagon was taken with each company, and six wagons of the heavy train, three ponton, one trestle and two chess, accompained the Battalion. The full division of bridge train could not be taken on account of lack of sufficient animals. With the exception of one day, the weather was fine. The roads were in excellent condition for teams the entire distance. The march from Silver Lake to St. Mary was made in a rain, beginning with a drizzle in the morning and increasing in violence, the Battalion entering St. Mary in a downpour. On this and subsequent days the roads were very heavy for foot troops, and the foot sections were put on the track of the Union Pacific R. R., accompained by an officer. The track was well ballasted so

that stepping the ties was not necessary, and marching on the track was found to be easy on the men but hard on their shoes, as the ballast was composed of a burnt clay containing many hard and gritty particles which cut the shoes rapidly.

3. A topographical officer was detailed for the march. The route followed was, with few slight variations, the one traversed by the Battalion last year. It was thought best not to attempt a new route this year in view of the great destruction of bridges and culverts caused by the summer floods. The work of the topographical officer was limited to checking, correcting and extending the map of last year. The data obtained will be incorporated in a new edition of that map as soon as time permits the work to be done.

4. The total enlisted strength of the Battalion on September 23d, the date of departure from the post, was 348, accounted for as follows:

Present.

Left at Fort Leavenworth:	
Sick in hospital,	15
In confinement,	6
Barrack guard,	4
Extra duty,	11
Special duty,	6
Total,	42
Leaving with the battalion,	251
Total present	293

Absent.

Detached service West Point, Ky	16
Detached service Fort Riley, Kas	13
Detached service Fort Crook, Neb	19
On furlough,	2
Absent without leave,	1
Other causes,	4
Total,	55

Total enlisted strength of the Battalion September 23d, 348

Sixty-five public horses, 84 draft mules, and 21 pack mules accompanied the Battalion. Seventeen horses and eight pack mules were with the detached section at Fort Crook.

5. On arrival at Fort Riley, the Battalion went into camp on the site designated, where it remained until the close of the maneuvers. The location of the site was slightly better than last year, the improvement made possible by a change in the positions of the hydrants. The police and sanitary conditions of the camp were satisfactory at all times.

Lieut. H. W. Stickle with the mounted section of Company A and a company pack train reached Fort Riley from Fort Crook on the 3d, and after reporting to the Commanding General of the post, joined the Battalion in camp.

6. Saturday and Sunday, the 3d and 4th, of October, were devoted to making and improving camp. A strong wind was blowing on Friday when the Battalion arrived which prevented the proper alignment of tentage. This was corrected the next day, drains dug, frames for kitchen flies erected, and stone hauled from the quarry on the hill for paving the areas adjacant to the hydrants and kitchens.

On Sunday afternoon, accompanied by Lieut. Stickle, commanding Company A, to which company the bridge train had been assigned for the trip, I made a reconnoissance of the river and selected two alternative sites for the bridge. One of these sites landed on the reservation on the Smoky Hill side, and the other did not. I ascertained definitely during the evening that the private land at the second site was under lease and available for landing the bridge, and as that site presented decidedly the best conditions, it was adopted. Monday morning the entire Battalion was turned out and the operations of hauling the bridge material from the park near the siding to the bank of the river at the bridge location, the construction of approaches at the hither end of the bridge, and the marking and construction of roads from the maneuver camp to the bridge were simultaneously prosecuted. Measurement of the river showed that it would be possible with the material at hand, consisting of that brought from Fort Leavenworth and the division of heavy train shipped from Washington Barracks, D. C., to lay two bridges at the then stage of the river with approaches so arranged that the bridges could be used on a rise up to three or four feet. As a reserve proposition, it was intended in case the river rose more than the amount named, to combine the two bridges in one, getting a length sufficient to cross the river at any stage short of a general overflow.

6. The first bridge was laid on Tuesday the 6th. A gale of wind was blowing downstream, which made the work of placing the boats

and anchors difficult, and the carrying of material on to the bridge still more difficult. Chess had to be kept edgewise to the wind with great exactness. Two men who allowed the wind to catch the chess which they were carrying, were blown overboard. Under these conditions, the work was slow and was not finished until afternoon.

As soon as a crossing could be effected, a company of the Battalion was put to work on the other shore laying out and constructing roads from the bridge to the beaten trail on Smoky Hill flat.

The first bridge constructed and communication established with the other shore, the building of the second bridge was postponed in the hope of receiving a car of the Washington shipment which had been lost and had not arrived. This car contained all of the small parts of the division, lashings, rack sticks, cables, etc. The car did not arrive, it may be remarked, until the last day of the maneuvres, and at my suggestion was returned to Washington Barracks with the seals unbroken. The second bridge was laid on October 15, the lacking material being supplied in part by fabrication on the spot and in part by stripping the light division, which was parked in camp, and intended for use in the problems should a bridge train be called for. The second bridge was placed a short distance below the first, parallel to it, and connected to it by lines stretched between the corresponding boats. The upstream anchors were attached to the upper bridge, the downstream anchors to the lower bridge. The upper bridge was set apart for mounted organizations and wagons; the lower bridge for foot troops. Separate approaches were made and connected with separate roads leading from the maneuver camp to the bridge on one side and from the bridge to the Smoky Hill flat on the other side, so that it was possible to move two columns in the same direction, or in opposite directions from the camp to the flat without crossing or any other interference. These facilities for quick movement of troops were, as a rule, not utilized by the commanding officers. In a majority of cases, all the troops of a command approached the bridge by a single road and left it in the same way.

During the crossing and recrossing of the entire division for the review the two bridges were in simultaneous use by troops only 11 minutes out of about two hours going and about the same porportion of time returning. If the second bridge had not been laid, there would have been no appreciable interference with the movement of troops as actually conducted.

The bridges were in almost constant use during daylight hours from

the time they were laid until they were taken up. No restrictions were imposed upon their use beyond posting notices at each end of the bridge to the effect that all non-military persons crossed the bridge at their own risk. Hay wagons, milk wagons, vegetable wagons, wood wagons, and an incessant stream of sightseers crossed and recrossed the bridge. Some statistics of the use of the bridges by troops, prepared by the commanding officer of the bridge company, are appended to this report.

One important departure from established types of construction was made in laying the upper or wagon bridge. It was designed to meet difficulties encountered last year and consisted in a third or middle rail laid over the middle balk and lashed to it through the chess which were notched at necessary places to allow the lashings to pass through. This proved to be a most valuable addition, and is earnestly recommended for adoption as a part of standard construction of bridges for heavy traffic. Without this middle rail, the particular chess which is loaded at any given instant, is deflected downward carrying the balk with it. The chess on either side not loaded remain practically straight, supported by the side balk. They not only take no share of the load, but also form an obstruction against which animals are very apt to stumble. With the middle rail, the edges of the chess are always in juxtaposition. When one is deflected, the adjacent ones are carried down with it, preventing them from getting out of register and also utilizing them to carry part of the load.

On account of the excessive traffic on the wagon bridge, the floor was covered with hay to reduce the wear on the chess. This covering was found to possess other advantages in lessening the noise and especially in encouraging timid animals which seemed to feel that where they had hay to walk on, it was safe to go.

The disposition of the bridges, the wagon bridge upstream and the foot bridge downstream, was adopted from force of circumstances and not from choice. It would probably be better, having in view the possibility of accident in the two classes of traffic, to have the position of the bridges reversed.

The provisional division, from the conditions in which it was organized, necessarily contained an abnormally large proportion of cavalry and artillery, and it would have been better in this case, and will probably be better in the general case, to have both bridges constructed alike, so that all classes of traffic could be sent over either one at will.

Cavalry and artillery habitually crossed the bridge without dismounting. Artillery, it may be remarked, is the easiest load which a ponton bridge has to carry. The deflections, it is true, are somewhat more abrupt than those for cavalry or infantry, but the oscillations, which are really the more serious strain on the bridge, are practically nothing. The hardest load on a bridge is cavalry, and the most troublesome load, to those engaged in its operation, is a pack train. I have observed that the oscillations of the bridge under cavalry mounted are not greatly more severe than those for cavalry dismounted, and are not so great but that they can be kept within reasonable limits by careful attention to the condition of the bridge. The frequent alternations of moisture and dryness made it impossssible to keep the balk lashings tight enough to give requisite lateral stiffness under mounted cavalry. The boats were therefore converted into a horizontal truss by two diagonal cables passing over the bows and sterns alternately and crossing under the middle of each bay. These could be set up by racksticks to any desired tension and gave very considerable increased stiffness to the bridge.

Aside from oscillations, the strains on the bridge are, in my opinion, less under cavalry and artillery mounted than under the same arms dismounted and leading. The intervals are much better kept and the deflections of the bridge are much more regular. There is also the very important practical advantage that the rate of motion for these arms mounted is about 25 per cent more than the rate dismounted, and the time of crossing is reduced in proportion. As a result of my experience last year and this year, I am convinced that the traditional requirement that mounted organizations shall lead across a ponton bridge is unnecessary, if not undesirable.

8. Besides the construction of the ponton bridges, other pieces of work were undertaken and entirely or mainly completed before the arrival of any other troops. Company B improved the main road in the vicinity of One Mile Crossing by some gravel fill and ditching. This company also collected materials and fabricated gabions, fascines, hurdles, etc., for use in the intrenchment problem.

Company C constructed a pile bridge over Three Mile Creek, and reconstructed one and repaired the others of the beam bridges on One Mile Creek. This company also collected material and constructed two spar bridges one-fourth size, one single and one double lock, over a ravine between the Engineer camp and the Battalion hospital.

Company D, in addition to preparing roads to and from the ponton bridges, repaired the existing bridges over the gullies and main channel of One Mile Creek between the Division Headquarters and the main camp.

During the maneuver period the Battalion, or parts of it, participated in the problems as follows:

In the afternoon of Friday, October 16th, Company D, Captain Raymond, marched to bivouac with the first brigade, and accompanied that brigade during the execution of the problem on the following day. The company was instructed to accompany a battery of artillery, assist in intrenching, and act as support.

On Saturday, October 17th, Company B, Captain Deakyne, formed a part of the brown force in the problem of that day. This company also was assigned to duty with the Artillery. Lieut. Stuart, on duty with the company, was assigned as topographical officer for the brigade.

On the afternoons of Tuesday and Wednesday, the 20th, and 21st, Captain Deakyne with his Company B, supervised the construction of intrenchments by infantry battalions, and on Friday, the 23d, Company B, with a detail from A Company, completed the intrenchments including the revetment of the lunette. On the afternoon of Saturday, the 24th, lectures and explanations relating to the intrenchments were given to the officers of the National Guard by Captain Deakyne and Lieut. Stuart.

On Thursday, the 22d, the entire Battalion particpated in problem No. 5, deployment of division, under command of Captain Flagler, the Major commanding having been directed by the Commanding General of the Division to accompany him as Engineer Officer on his staff. The report on this problem is appended. Late in the afternoon of the 22d, Company C, Captain Flagler, marched to Eskerson's ranch and joined the force under General Barry in bivouac in that vicinity. The company particpated in problem No. 6 on the succeeding day. The company was assigned to reconnoitering the creek for suitable crossings, but at an early stage of the problem was put out of action by the capture of its train and the horses of its mounted section. On Friday, the 23d, Company D, Capatin Raymond, participated in this problem on the opposing side under command of General Bell. The company was assigned to the extreme right of the line and directed to make a rapid reconnoissance to the front.

On Saturday, the 24th, the Battalion participated in the review division, being assigned to a position on the right of the line.

On Monday, the 26th, the Battalion participated in attack and defense of position, problem No.7. The Battalion Commander was assigned to the left of the position, extending across the low ground between Reservoir Ridge and the Republican River. His report on this problem is appended.

On the afternoon of Thursday, the 29th, the Battalion joined the force under command of Colonel Augur, went into bivouac on Republican Flat, and participated in the night march and morning attack of the succeeding day. The Battalion was assigned to a position in the center of the line with an infantry regiment on each flank. A copy of the report on this problem is appended.

10. The construction of intrenchments, referred to above, involved the laying out and actual construction of a lunette for 200 men, lines of trench and echelon in four stages of construction, lying, kneeling, standing, and complete, and short lengths of Spanish and Boer trench. Except as indicated above, the labor was performed by details from the infantry regiments. The officer in command of the trenches was Lieut. Col. R. H. R. Loughborough, 6th Infantry. The details for working parties were made by battalions as follows: October 20th, afternoon, one battalion 2d Infantry, 126 men; one battalion 21st Infantry, 119 men; one battalion Texas provisional regiment, 148 men; one battalion, 2d Infantry, Nebraska National Guard, 136 men; October 21st, afternoon, one battalion, 25th Infantry, 192 men; one battalion, 12th Infantry, 99 men; one battalion, 6th Infantry, 232 men; one battalion, 2d Infantry, Kansas National Guard, 105 men.

One battalion, 1st Infantry, Kansas National Guard, reported October 21st, to late to commence work.

The labor expended on the line by infantry troops was about 3,500 hours for one man, or 437 eight hour days. The lunette was completed and Spanish and Boer trenches dug by Company B of the Engineer Battalion, assisted by 25 men from Company A. This force worked one day.

11. The foot bridge was dismantled on the afternoon of Thursday, the 29th, and on Saturday, the 31st, the wagon bridge was dismantled, and hauling material to the railroad loading platform began. On Sunday, November 1st, the hauling was completed and loading began, the cars having been set on the siding about noon. The loading of bridge material was completed early on the morning of the

2d, and the company property and baggage to be sent by rail was loaded immediately thereafter, including the greater part of the tentage. The Battalion was placed in bivouac for the night. During the night four cars were dispatched to Washington, D. C., and a special train containing the Leavenworth equipment, with a train guard, was sent out.

12. At 9:40 A. M. on the 3d the return march to Fort Leavenworth was begun. On account of several days' rain the roads were in very bad condition, and the foot sections were put on the railroad track at once, and did not leave it except to make camp, until about four miles from Topeka. The mounted sections and baggage and pack trains made the first day's march to Manhattan without very great difficulty. The road presented a hard, smooth bottom, covered by three to five inches of soft mud, which offered comparatively little obstruction to traction. On the second day's march, Manhattan to Wamego, greater difficulties were encountered as the roads were heavier, cutting through in places, and some very difficult hills were encountered. The mounted sections and baggage train reached camp at Wamego late in the afternoon. From three miles west of Wamego a report was sent forward to me that one mule of the bridge teams was down and the rest manifestly exhausted. Knowing the condition of the road ahead of them, I directed that they unhitch and remain where they were for the night. A mounted section was left with them as guard, and forage and rations were sent back from camp.

The order of march adopted was to have the mounted sections follow the train closely, with orders, in case a wagon was seen to be in trouble, to ride forward, dismount and man the drag ropes. The policy was pursued from the beginning of sparing the mules any standstill pulls. They were reserved for the steady drag of the average road, and all pulls of unusual difficulty were made mainly by the men. This arrangement was pursued throughout the trip, and but for it, in my opinion, the animals would not have lasted through.

13. Next morning the bridge train started at 7 o'clock, and it required three hours of very hard work to make the three miles to Wamego. The teams were rested until noon; dinner was served at 11 o'clock, and at 12 the march was resumed. Camp was made for the night in a field of mud north of Belvue, with an extremely difficult piece of road just ahead, which it was evident that the mules could not get through at the end of a day's march. Next morning the men were required to carry their bedding out and deposit it in the worst parts of the road, and with this assistance and the teams fresh, this very heavy piece of road was passed without much trouble. The day's march extended to Rossville, a

total distance of about 14 miles. The next day, a march of 17 miles was made from Rossville to about two and one-half miles north of the Reform School near North Topeka. The latter part of this march was very heavy and the mules came in nearly exhausted. The next day's march was made to Meriden. I had hoped to get on as far as Ozwakie, which would have made up the lost time and put the Battalion on the schedule arranged before leaving Riley, but the condition of the animals on reaching Meriden was such as to determine me to go into camp there. The next day Ozwakie was reached about 11 A. M., and from this point the condition of the roads began to rapidly improve. The march was continued to a point about seven miles east of Ozwakie. The next day's march was to three miles west of Easton, and the next to Fort Leavenworth, which was reached at 1:30 P. M., on the 11th, the day lost during the first part of the march having been made up. Men and animals came in in very good condition.

14. There were very few cases of foot soreness on the march in either direction, and those that occurred were, in nearly every case, due to worn out or defective shoes. One bad case was that of a man whose shoes were too small although he had drawn the largest size issued by the Quartermaster's Department. It would be very desirable, in my opinion, to have arrangements made by which men attending maneuvers who have to march in either or both directions, could draw footwear at Fort Riley. It is difficult to make adequate provision in advance because the wear on shoes is variable and uncertain. It is not always possible to tell, even by a close examination, whether a pair of shoes apparently in good condition with last through a march of 140 miles, or not, and whether they do or not depends quite as much on the condition of the road during the march as on the condition of the shoes at its beginning. A great many men of the Engineer Battalion were obliged to wear black shoes with the field uniform during a part of the maneuvers because their tan shoes in which they made the march were completely worn out.

The following statistics on this subject are taken from the report of Capt. R. R. Raymond, Corps of Engineers, commanding Company D: "Great care was taken before leaving Fort Leavenworth to see that all the men were provided with shoes in good condition. Of the new shoes used 21 per cent failed before reaching Fort Riley and 87 per cent failed on or before the return march. Of the shoes that were not new but in good condition, 54 per cent failed on the way to Fort Riley, and 88 per cent failed before the return to Fort Leavenworth. These shoes cost $2.20 per pair. I am convinced that a shoe can be obtained for not more than $5 per pair that will be much cheaper per mile than those issued, and will be more comfortable because worn longer after breaking in."

Captain Raymond also recommends that the shoes be provided with Hungarian cone-head nails on the soles to give a more secure footing on dry grass or rock, the former especially. He estimates that in rough country over grass burned by the sun such shoes will increase the indurance of the men 25 per cent. I have myself observed the effect of dry grass in this part of the country on the soles of shoes. It polishes them like glass and makes walking extremely difficult, as the shoes slip on the grass almost as they would on ice. Shoes so prepared would not be the most suitable for general use, but if they could be provided especially for field service, it would, in my opinion, be very desirable to do so.

Capt. Raymond also noted the fact that the shoulder straps of khaki blouses were a source of great inconvenience by catching in passing through the brush. This I have also noticed, and I concur in Capt. Raymond's recommendation that the straps be discarded.

15. All officers on duty with the Battalion were present during the march and maneuvers, except Lieut. N. E. Bower, who was absent on detached service at West Point, Ky., until October 17th, and was on special duty as assistant to the Chief Umpire after that date; Lieut. W. G. Caples, who commanded the train guard from Fort Leavenworth to Fort Riley, and Lieut. C. H. Knight, who commanded the train guard from Fort Riley to Fort Leavenworth.

In response to a request made by me to the Chief of Engineers for additional officers during the maneuvers, 1st Lieut. A. B. Putnam, Corps of Engineers, was temporarily attached to the Battalion, and assigned to duty with Company C. Lieut. Putnam served as topographical officer on the march over, and in command of the mounted section during the maneuvers. He was relieved on the 31st of October and returned to Fort Leavenworth by rail, and thence to his permanent station at Pittsburg.

16. One of the most significant lessons of the maneuvers of this year is the demonstration of the necessity for having officers and some, at least, of the non-commissioned officers provided with compasses which can be read without outside illumination. If watches with fluorescent dials, which could be read at night, can be obtained, their use would be a great convenience.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

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Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

HEADQUARTERS, 1ST BATTALION OF ENGINEERS,
CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,
October 23, 1903.

THE ADJUTANT GENERAL,
BLUE DIVISION,

SIR:

I have the honor to submit the following statement of the movements of the 1st Battalion of Engineers in the problem of yesterday.

The Battalion, less the foot sections of one company, and the mounted sections of two companies, was in position in column on the Ogden road, east of One Mile Creek at the appointed time. At 8:30 A. M., orders were received for the formation of a line of battle in which the Battalion was directed to accompany the Artillery and to assist in intrenching.

Following the Signal Corps, the Battalion moved at once across the bridge and halted in the road at the top of the hill west of the bridge, to wait for the Artillery to come up.

At this point verbal instructions were received from the Division Commander to follow the Artillery on a trail leading to the high ground east of One Mile Creek. The column was countermarched, overtook the Artillery, and found the place assigned to it in column. After performing the work assigned to it, the Battalion took position under cover in rear of the Artillery position west of Morris Hill, and awaited instructions. When the recall rocket was seen, the Battalion returned to camp.

The foot sections of one company, not in attendance, were on duty at the ponton bridges. The two mounted sections not present with the Battalion, were with the advance guard.

By order of the Division Commander, I accompanied him as Chief Engineer of the Division, and the command of the Battalion devolved upon Captain Flagler. Captain Flagler's company was ordered into bivouac immediately upon its return from this exercise. He was not able to submit this report himself, from lack of time, but gave me the data from which it is made up.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

STATISTICS OF THE USE OF BRIDGES AT FORT RILEY FROM OCTOBER 16TH TO OCTOBER 30TH.

Foot Bridge.

Twenty-five regiments of infantry, 2 companies of infantry, 1,222 foot men (mostly civilians); 5 light wagons, 2 pack trains, and the mounts accompanying foot troops also crossed the bridge.

Wagon Bridge.

Twenty-three regiments of infantry, 44 companies of infantry, 121 troops of cavalry, 32 batteries of artillery, 16 mounted sections of engineers, 6 dismounted sections, 1,727 individual horsemen, 751 footmen, 206 one-horse vehicles, 703 two-horse vehicles, 386 four-mule wagons, 73 six-mule wagons, 4 pack trains, 214 loads of hay, 1 automobile, 4 Colts automatic R. F. guns.

CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.:
October 26, 1903.

THE ADJUTANT GENERAL,
BLUE FORCES.

SIR:

I have the honor to submit the following report of the [illegible] the left of the position occupied in the problem of [illegible]. I was assigned by the order of the Brigade Commander [illegible] mand of the left of the line, consisting of [illegible] guns at the extreme southern end of [illegible] Ridge, and [illegible] the Republican bottom from the [illegible].

The forces occupying this line consisted of [illegible] Battalion of Engineers, less the four sections of one company, and [illegible] Battery, Field Artillery, commanded by [illegible].

The Battalion of Engineers [illegible] the ground. Instructions were given [illegible] from the edge of the timber [illegible] Heights to the levee of the artillery [illegible] the right and Company [illegible] of the [illegible] bank of the river, was sent to [illegible] between the levee and the [illegible] north of the field. The levee was assailed [illegible] positions were prepared [illegible] siege preparations. The [illegible] than the right, the latter resting near the pump house. The second position was between the advance and final lines, about 100 yards west of the athletic field. Safe avenues of retreat from each of the two front lines to the next one in rear were explored and prepared by some artificial additions to the natural cover. The men were conducted over these lines to make sure that they understood where they lay and how to use them. A picket was sent across the highway bridge. A kneeling trench was constructed on the main line, and cover for men lying down, and in part kneeling, was obtained on the forward lines mainly by digging and throwing the earth to the rear without raising parapets. These preparations were complete before 9:00 A. M.

As soon as instructions for the foregoing work had been given, I proceeded to the center and reported in person to the Brigade Commander. He instructed me to place Lieut. Clark's platoon of Artillery, and I selected the position occupied by two guns with complete natural cover from all practicable Brown Artillery positions. I instructed Lieut. Clark to pay no attention to Artillery fire unless he could catch a battery changing position and presenting a good target, but to fire on all bodies of Infantry and Cavalry, mounted or dismounted, in sufficient numbers to make a reasonably good target.

At 7:15 A. M. Lieut. Stuart with a mounted section and a pack mule containing a demolition outfit was sent forward to reconnoiter along Sherman Heights to and beyond the Governor Harvey road. Lieut. Stuart was instructed to send a non-commissioned officer, a mounted private and the pack mule direct to the Washington Bridge over the Republican River, to prepare the bridge for demolition and to arrange to have the bridge destroyed on the approach of a Brown force, but not otherwise. Under these instructions the bridge was blown up at 10:10 A. M., a squadron of cavalry having been observed coming down the Governor Harvey trail.

There was no firing on my front during the day, except on the extreme right where Cavalry repeatedly threatened and approached through the draw leading under the stone culvert. Part of a company was stationed on the west edge of the ravine commanding the trail through it and a troop of Cavalry operated similarly on the right bank with patrols up toward the head of the draw.

About 10:30 I received information that two troops of cavalry had crossed the Washington Bridge. This information subsequently proved to be incorrect and only the Umpire, and it is said, some Blue prisoners, crossed the bridge, where the two troops crossed by swimming. I may note here, if true that prisoners were taken across the bridge, it was in my opinion an improper proceeding. A few minutes later the officer in command at the bridges notified me that Cavalry had been seen on the Junction City road. He was ordered to advance his outposts and sending of reinforcements to the bridge was begun. First, the mounted section of B Company was sent, then the mounted section of D, then a non-commissioned officer and ten men from the foot sections of D, then another detachment of the same size from the same company. Finally the Captain of B Company on the extreme left seeing nothing in his front and hearing heavy firing at the bridge, moved a part of his foot sections without orders to reinforce the bridge. In all about 70 men were sent to reinforce the bridge guard in the course of 20 minutes. In addition to the personnel of this defense the bridges had been interrupted to traffic by removing a small portion of the roadway on each.

The guard on the ponton bridge was doubled at 6:30, and the officer in charge directed to patrol the woods at the south end of the bridge; stand off any Brown force that he was able to handle, and if a larger force appeared to hold it in check and take up the bridge. No Browns approached the bridge from the south side of the river, but three men came up on the north bank and claimed the capture of the officer in charge. A few seconds later they were surrounded by the bridge guard, themselves captured, and the officer in charge of the bridge released. Later the bridge was attacked by a somewhat larger force. I have information that these men were cavalry troopers who crossed the bridge lying on the bottom of a trolley car. No other incident worthy of report occurred until the close of the exercise.

Very respectfully, (Signed) SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,
October 28, 1903.

COLONEL E. Z. STEEVER,
CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.

SIR:

I have the honor to submit the following, supplementary to my report on the exercise of October 26th, in compliance with your verbal request of this morning.

The three bridges on the left of the position and crossing the Republican River had all traffic over them interrupted by removal of a part of the roadway. The trolley bridge had rails and ties removed from the far end, and piled on the near bank. The railroad bridge had rails removed and thrown in the river, and ties removed and burned. This was for a short length at the farther end of the bridge. The highway bridge had the flooring removed at the farther end and planks laid for men to cross in single file, to enable the pickets on the farther side of the river to return across the bridge when necessary. Men, tools, and all facilities for accomplishing these results were at the bridge in ample time to complete the work by 7:30 A. M.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

HEADQUARTERS, 1ST BATTALION OF ENGINEERS,
CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,
October 30, 1903.

THE ADJUTANT, BLUE FORCE,
CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,

SIR:

I have the honor to submit the following report of the movements of the 1st Battalion of Engineers in the affair of this morning.

The Battalion left bivouac on the Republican Flat at 4:00 A. M., taking the position assigned to it in column in rear of the 21st Infantry. Owing to darkness and the rapid rate of march the head of the column passed the place where it had been intended to leave the Harvey road, and marched to the junction of Estes road. The latter was taken for a short distance and formed the Battalion for action with one company in reserve and two companies in the line; each of the latter providing its own support. The space between the companies was filled by 10 mounted men. Ten mounted men patrolled also on the right of the right company, and 10 on the left of the left company, in the attempt to secure touch with Infantry regiments on the right and left, respectively. Just as the column left the Harvey road, the sky clouded over obscuring all the stars. The direction by compass which it was supposed would strike the south flank of

Forsyth mound was given the Company Commanders and the advance began. The two companies in the firing line advancing in line of squads with scouts in front. The advance was delayed by the darkness, and the failure to gain touch with organizations on either flank, and at daybreak the Battalion found itself behind a ridge with its right resting on Forsyth mound. A battery was found on the mound with an Infantry regiment deployed on its right. This regiment proved to be the 21st and the Battalion was moved by the right flank under cover of the ridge, to the position in line assigned to it on the right of the 21st. The 2d was found on our right and rear, the interval between the two being so small that the two companies on the firing line were brought together in line of skirmishers, the interval between them being eliminated. When the advance began the Battalion moved forward directing on the right Battalion of the 21st, gaining ground to the right and swinging to the left, to conform to the movements of that regiment. A Brown outpost on the spur southwest of Wolf Canon was driven in, and the Battalion crossed the canon with the left near the spring and under fire from a ridge in its front. This ridge was gained, the force holding it falling back and the Battalion still turning to the left advanced to a position on the spur west of the saddle back facing slightly west of north. At this point the action terminated. When the Battalion was about half way up the northern slope of Wolf Canon, and just after the reserve had been put in the line, cease firing was sounded and the Battalion halted and remained in position for a few minutes. Meanwhile the right company which had gained the ridge was being fired on by the enemy and was returning the fire. Under these circumstances, without waiting for the signal to commence firing, the rest of the line was advanced on the ridge to the support of the engaged company.

It was broad daylight when the Battalion first came under fire, but a light rain was falling and the crests of the ridges opposite were obscured by mists. During the early part of the action, the flash of the rifles could be seen. Toward the close of the action the men themselves could be made out at short ranges. Between these two periods was an interval when it was difficult to get any target whatever.

The heaviest part of the action appeared to be to our left. While in Wolf Canon the 21st Infantry moved by the left flank and we lost touch with them since we could not follow the movement on account of being engaged in front. The resistance on our part of the line was comparatively light and the Battalion advanced almost continuously throughout the action. At this writing no casualties have been reported.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

REPORT OF CAPT. FLAGLER, CORPS OF ENGINEERS, COMMANDING COMPANY C.

COMPANY C, 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANS.,
November 17, 1903.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS,
Fort Leavenworth, Kans.

SIR:

I have the honor to submit the following report of the operations of Company C, 1st Battalion of Engineers, during the recent maneuvers at Fort Riley, Kans.

The company left its station at Fort Leavenworth, Kans., September 23, 1903, and proceeded by marching with the Battalion to Fort Riley, arriving there October 2, 1903.

Lieut. A. B. Putnam acted as Topographical Officer on the march and prepared a map en route.

The composition of the company was as follows:

Two officers, 47 enlisted men in foot sections, 17 enlisted men in mounted sections, 2 cooks, 4 teamsters, 2 packers.

While at Fort Riley work performed and maneuvers participated in were as follows:

Large details were furnished to assist Lieut. Stickle in laying two ponton bridges across the Kansas River.

October 7th to 19th. The mounted section under Lieut. Putnam constructed a single bay log bridge across One Mile Creek and repaired approaches to other bridges across this creek previously built by the garrison. The mounted section under my direction constructed two spar bridges across gully to west of camp. These bridges were miniature, being one-fourth scale intended for illustration; one was single lock and one double lock; they afforded foot passage from the Engineer camp to its Field Hospital.

During this period Lieut. Caples with the foot sections constructed a pile trestle bridge across Three Mile Creek on the Ogden-Riley road. I quote his report description of the bridge.

CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,
October 28, 1903.

CAPT. C. A. F. FLAGLER,
CORPS OF ENGINEERS, U. S. A.,

SIR:

I have the honor to submit the following report of the construction of a bridge over Three Mile Creek on this reservation.

Project: To construct a pile trestle bridge of material that could be obtained in the vicinity of the work, the completed bridge to be of a permanent nature and capable of carrying all arms of the service and their trains.

Construction: Work was commenced on October 6, 1903, with a detachment of troops from Company C, 1st Battalion of Engineers. The site for the bridge was selected just below the present ford on the Fort Riley-Ogden road. The length between abutments at this point was found to be 43 feet. It was decided to make the bridge consist of three trestles and two abutment sills. The height of the trestle above the mean low water of the creek to be 5.4 (five and four tenths) feet exclusive of the cap. It was decided to use piles of nine feet length and not smaller than six inches at the smaller end. When the piles were cut it was found that the smallest was about eight inches at its smallest end. Each trestle consisted of five such piles spaced three feet center to center and a cap covering the piles and pinned to them. The caps were of round timber about 12 inches in average thickness and grooved to fit the piles. A small sapling about four inches thick was split and the two parts spiked to the piles as cross bracing. The bearers between trestles consisted of round timbers about 12 to 14 inches in average thickness. They were left to project about three feet beyond each trestle. The floor consisted of round timbers 14 feet in length and not less than 0.2 of a foot in thickness at the small end and of split timber of the same length and not less that 0.4 of a foot in thickness at the small end before splitting, and of some shorter pieces of the same thickness. Three trestles were built. The spacing of the trestles was as follows: Beginning on the Fort Riley side of the stream, from sill to first trestle, seven feet; from first trestle to second trestle, 12 feet; from second trestle to third trestle, 12 feet; from third trestle to sill, 14 feet. In practice this span was found to be too long and earth and gravel were filled in under it so as to leave only 12 clear

feet between supports. The crawl of the bridge was taken up by burying at each end a sill of 14 inches in average thickness and pinning the roadway bearers to these. The crawl was further taken up by placing cross bracing between trestles two and three, making of them a braced cube. The caps were connected to the piles, the bearers to the caps and sills and the side rails to the caps and sills by wooden drift pins. These were made with a small wedge in the lower end and driven into place with a maul. At first it was attempted to fasten the side rails with wire, but it was found that the pins brought them into so much closer contact that they were first pinned and then wired. All flooring that was not brought into good contact by the side rails was spiked down. Spikes were however, only used where they were considered as absolutely necessary. The cracks in the floor were filled with brush and twigs, and the floor then covered with a thin layer of earth. The work was all done by hand. The piles were all driven with a maul. Those in the first trestle were driven by men standing on the shore and those in the second trestle by men standing in a wagon, as were those also in the third trestle. The shock of the wagons coming on and off the bridge on the flooring at the end was provided for by burying the sills and making the ends of the flooring of heavy, rough-squared timbers, brought a little below the natural service of the earth. In driving the piles for trestles No. 2 and 3 a layer of gravel two and one-half feet thick was encountered. This layer offered so much resistance that piles could not be driven into it without splitting. This layer was cut through and the piles driven until they would not sink more than half an inch under eight heavy blows of the maul. The holes were then filled in with the material excavated. The spacing of the piles was three feet. Rain for several days, the time occupied going to and from work, and the fact that all the timber had to be culled and all brush cleared up caused the work to go slowly. The bridge was completed October 17, 1903. A road was then cut to permit the easy access of wagons to the bridge. As soon as the bridge was completed it carried a battery of Artillery and a brigade of Cavalry without exhibiting any signs of weakness. Up to the date of this report, it has carried successfully every load which has been placed upon it. Drawing showing the plan, section and elevation of the bridge and photographs showing the manner of driving piles and the appearance of the completed structure are hereto appended.

Very respectfully, your obedient servant,

WM. G. CAPLES,
2d Lieut., Corps of Engineers.

Work on this bridge was much delayed by heavy cold rains. Drawings and photographs are omitted from this report.

October 22d. The company in Battalion took part in a deployment of the Division. The Battalion in position was held in reserve in a draw a little west of Morris Hill, and in rear of Snow's Battery; C Company, while the Battalion was in reserve, was instructed to intrench Snow's Battery. The entire company performed the work, digging three gun pits in about one hour. The work was performed with ordinary tools and with no attempt at concealment. Lieut. Caples with two enlisted men made a sketch of this deployment.

October 22d and 23d. The company was attached to Gen. Barry's Brown Force for maneuver to northeast of reservation. I quote from my report to Gen. Barry describing movement as follows:

The company left its camp near the Artillery post at 4:30 P. M. * * * with one tool wagon, two advance guard bridge train wagons, took route, Packer's Camp, Cemetery and Ogden and Keats road, as directed in written orders of October 22d (Headquarters Brown Division), and went into bivouac just north of Seven Mile Creek on above road at 8:00 P. M.

In accordance with instructions in Field Orders No. 1, I detailed 2d Lieut. W. G. Caples as Topographical Officer, to prepare map showing action on the 23d. This map is submitted herewith.

October 23d. Left bivouac 6:15 A. M., marched by road to ford on Seven Mile Creek below Taylor's, sent mounted section along north side of creek to find practicable crossings between Taylor's ford and Schoolhouse No. 73. Report of these crossings received about 9:00 A. M. At 10:15 A. M. the entire company, under command of Lieut. A. B. Putnam, left Eskerson's with the Artillery of the 6th and 19th Field Batteries, as directed by Field Orders No. 3, Headquarters Brown Division. The Artillery took up a trot and then a gallop, leaving the company behind. About 10:25 A. M. the company was fired upon from the hills to east of road, and the wagon train and mounted section ruled out of action by Major Zinn, Umpire.

The foot sections returned the fire and then fell back through the woods, crossed Seven Mile Creek about half a mile below Taylor's Ford and rejoined the Artillery in position on a hill southeast of the Ford about 11:30 A. M. About 11:45 A. M. the Artillery fell back at a gallop, the company at a double time. I took command of the company at this time. Two pieces halted in an open space in the creek bottom, and I formed the Company sheltered behind the bank on the creek between these guns. A heavy fire was coming from the hills to the right and left front of the company. Soon the 2d Nebraska appeared at the stone fence on the east side of the open space in front of us. I fired at them for some time, until they left cover and charged across the open. They halted at 150 yards, and Capt. Preston, Umpire, ruled the company out of action.

October 24th. The company took part in review of all troops held on the Smoky Hill Flats.

October 26th. The company in Battalion took part in the defense of a position. The Battalion was on the left of the position, extended across the Republican Flats, east and west through the race track. C Company extended from the Junction City road to the foot of the bluffs about 300 yards south of the pumping station. The company constructed kneeling trenches on this line. One platoon as ordered by the Battalion Commander took an advanced position under my command just north of the pumping station. This platoon constructed two lying trenches, one on each side of the road, utilizing some 6-inch iron pipe found at the pump house for parapets. These parapets were completely concealed with dead grass. I placed scouts on the bluffs at my right. About 11:00 A. M. these scouts gave warning of the advance of Cavalry patrols of the enemy approaching my right flank. I immediately left the trenches and took up a position to the right rear, covering an opening in the bluffs on my right flank. In this position I exchanged several volleys with a Cavalry troop which attacked us dismounted. This troop withdrew and hearing firing in the rear, I fell back on the trenches, but found them deserted. Hearing firing on the hill above the right flank of my trenches, I climbed the hill with the platoon and found the Battalion Commander there with the remainder of the company. The problem ceased at this point.

Lieut. Caples with the mounted section during the above movements assisted in the defense of a bridge across the Republican River on our left rear. This bridge was attacked by a Cavalry force which had forded the river above. The attack was repulsed.

October 29th and 30th. The company in Battalion went into bivouac on the Republican Flats; the force was in blue under command of Col. Augur. At 10:30 P. M. orders were received for a night attack to be made the following morning on the Brown force, said to be encamped on the Saddle Back. The Battalion left bivouac at 4:00 A. M. and marched by the Governor Harvey road to the junction with the Estes road. From this position the Battalion moved to its position in the center of a line extending from Morris Hill to Forsyth Hill and facing northeast. C Company was on the right of the Battalion and by instructions of the Battalion

Commander I patrolled with mounted men to my left keeping touch with B Company, Engineers, and to my right to keep touch with the 2d Infantry, supposed to be there. I never found this regiment at any part of the maneuver and suppose it to have been lost. Some confusion as to direction arose in taking position, owing to heavy clouds and rain which obscured the stars, and to orders forbidding smoking and lighting matches which prevented use of compasses. I used the wind alone for direction, but it veered about 45° to the south from east causing a considerable error. However, at daybreak the company was very nearly in its proper position. The advance began promptly at daybreak and continued to the east until we had crossed Wolf Canon. This advance was opposed on my front only by two troops of Brown Cavalry, which occupied each successive ridge and fired on us. I halted at each stand that they had made and fired by volley and at will, about 10 rounds, and resumed the advance. The Cavalry fell back at each advance. The close of the maneuver at 8:30 A. M. found the company in position on the right of the Battalion firing at a dismounted line of Cavalry at about 350 yards.

The company left Fort Riley with the Battalion November 3d, and proceeded by marching to Fort Leavenworth, arriving November 11, 1903.

Changes in the company during the maneuvers were as follows:

2d Lieut. W. G. Caples, joined October 2d from detached duty.

1st Lieut. A. B. Putnam, relieved October 31st.

Six enlisted men joined from detached service.

One enlisted man left sick at Fort Riley in Base Hospital.

Very respectfully,

C. A. F. FLAGLER,
Capt., Corps of Engineers,
Commanding Company C, 1st Battalion of Engineers.

REPORT OF CAPT. DEAKYNE, CORPS OF ENGINEERS, COMMANDING COMPANY B.

HEADQUARTERS OF COMPANY B,
1ST BATTALION OF ENGINEERS, U. S. ARMY,
FORT LEAVENWORTH, KANS.,
November 18, 1903.

THE ADJUTANT,
FIRST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANS.

SIR:

I have the honor to make the following report of Company B, 1st Battalion of Engineers, from September 23 to November 11, 1903.

September 23d to October 2d. March to Fort Riley; two officers and 68 enlisted men. Left at Fort Leavenworth, one officer and eight enlisted men. At West Point, Ky., four enlisted men. On furlough, one enlisted man.

October 3d and 4th. Ditched the company tents and dug sink. Entire company. Inspection at 9:00 A. M., October 3d, 1903.

October 5th. Engineer construction:

Preparing approaches to ponton bridge, Lieut. Stickle, one non-commissioned officer and 15 privates. Lieut. Caples, unloading ponton material, nine non-commissioned officers and 14 privates.

October 6th. Work on approaches to bridge, eight non-commissioned officers and 29 privates.

October 7th, A. M. Hasty intrenchments with small pick and shovel, two officers, and nine non-commissioned officers and 25 privates.

P. M. Same as in the morning, two officers, eight non-commissioned officers and 15 privates.

In ordinary soil a man can get appreciable concealment and some cover in six minutes, and fair cover in 15 minutes.

P. M. Collecting material for approach to ponton bridge, one non-commissioned officer and 10 privates.

October 8th. Ditching road at One Mile Creek and placing gravel on same, two officers, 10 non-commissioned officers and 24 privates; using picks, shovels, one plow and three scrapers.

October 9th, A. M. Eight non-commissioned officers and 28 privates, same as October 8th.

P. M. Men worked cleaning up clothing and equipments.

October 10th. Battalion inspection in the Field Order; two officers and 62 enlisted men.

October 11th. Sunday.

October 12th, 13th and 14th. Rain; no work.

October 15th. Engineer construction:

A. M. Two non-commissioned officers and 18 privates assisted in construction of ponton bridge. Two non-commissioned officers and six privates collecting material for fascines and gabions.

P. M. Eight non-commissioned officers and 18 privates constructing fascines, gabions and hurdles.

October 16th, A. M. Nine non-commissioned officers and 28 privates cutting material and making fascines, gabions and hurdles.

P. M. Eight non-commissioned officers and 24 privates completed work commenced in A. M.

October 17th. Company formed a part of the Brown force under Gen. Barry in Problem No. 2, formation of outposts. Strength, two officers and 49 enlisted men. Left camp 7:20 A. M., crossed river on ponton bridge and reached crest of Grant Ridge 8:45 A. M., where company took position near Artillery to dig gun pits if required. (No gun pits were necessary). Attack was made by Blue force 1:25 P. M. Company was posted on right of field battery to act as support and to guard against turning movement on right flank. Action lasted one hour. Returned to camp 3:30 P. M.

October 18th. Sunday.

October 19th. Selection of site for trenches and laying out lines for same on Smoky Hill Flat. Preparing material for revetment and collecting tools for the work.

October 20th, P. M. Two officers and 11 non-commissioned officers on instruction of regular and state troops in construction of hasty intrenchments. Had four Battalions as follows: 2d Infantry, 21st Infantry, Texas and Nebraska National Guard.

October 21st. Continued work commenced October 20th, revetting

parapet in lunette. Constructed Spanish and Boer trenches, two officers and 37 enlisted men. Had four Battalions at work: 6th Infantry, 12th Infantry, 25th Infantry, Kansas.

October 22d. Deployment of entire Division. Company went as part of the Battalion. Left camp at 7:30 A. M., returned at 2:20 P. M. Company remained in reserve during the problem. Strength, two officers and 62 enlisted men.

October 23d. Completing work on intrenchments, including revetment in lunette, two officers and 44 enlisted men. Wire entanglement constructed outside of lunette.

October 24th. Review of entire Division. Left camp at 7:40 A. M., and returned at 11:45 A. M., two officers and 62 enlisted men.

P. M. Lecture to state officers on intrenchments by the Company Commander.

October 25th. Sunday.

October 26th. Company formed part of the Battalion with Blue force on problem of "Attack and Defense of a Position." Company occupied left flank of position, resting on Republican River. Mounted section was employed first in scouting and later on firing line. Foot section was posted at 600 yards firing point of rifle range. No direct attack was made on this part of position. An attack was made on left flank but was repulsed by mounted section of company and mounted sections of C and D Companies. Strength present, two officers and 55 enlisted men.

October 27th. Field day; company took no part.

October 28th. Attack and defense of a convoy. Light bridge train participated, one sergeant, two privates (teamsters) Company B.

October 29th. Left camp at 1:00 P. M. as part of the Battalion and marched to Republican Flats for bivouac, two officers and 56 enlisted men.

October 30th. Left (bivouac) at 4:00 A. M. and proceeded northward and deployed for attack on Brown forces. Participated in the attack. Returned to camp at 9:30 A. M., two officers and 56 enlisted men.

October 31st. Assisted in dismantling ponton bridge, two non-commissioned officers and 17 privates. Company was mustered.

November 1st. Loading ponton material, four non-commissioned officers and 20 privates.

November 2d. Completed loading ponton material and company property, one non-commissioned officer and six privates. Company turned out 8:30 to 10:00 P. M., on account of fire in hay sheds.

November 3d. Started on return to Fort Leavenworth, Kans., 9:40 A. M.

November 11th. Arrived at Fort Leavenworth, Kans., two officers and 71 enlisted men.

Very respectfully,

HERBERT DEAKYNE,
Captain, Corps of Engineers,
Commanding Company B, 1st Battalion of Engineers.

REPORTS OF CAPT. RAYMOND, CORPS OF ENGINEERS, COMMANDING COMPANY D.

FORT LEAVENWORTH, KANS.,
November 18, 1903.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS,
Fort Leavenworth, Kans.

SIR:

I have the honor to submit the following report of the operations of Company D, 1st Battalion of Engineers, during the recent maneuvers at Fort Riley, Kans.

The company marched from Fort Leavenworth with the 1st Battalion of Engineers, under the command of Major S. S. Leach, Corps of Engineers, and arrived at Fort Riley October 2, 1903, going into camp at that post.

From this date until October 9th, details were furnished for the construction of bridges. This work not being under my supervision, no report will be made here concerning it. The company was also engaged in laying out and marking with sign boards two roads leading to the two ponton bridges, and from these bridges to the Smoky Hill Flats. Two gutter bridges were built on these roads, brush was removed and about 400 feet of road in loose sand was curduroyed with sun-flower stalks. None of this work comprised any important engineering features, but it is interesting to note that three methods were employed in placing the sun-flower stalks in position. At first the stalks were laid directly upon the surface of the sand, and were covered by sand shoveled in from the sides. This road lacked lateral support and tended to flow out into the ditches formed by borrowing the sand. These ditches also made it difficult for wagons to turn out of the road when necessary. The plan was then tried of making a shallow excavation the full width of the road, laying the stalks transversely to form a layer about as thick as the depth of the cut, and backfilling the sand. This method is better than the first, but there is still a tendency to cut ditches, and the road is not uniformly filled with sand, the edges appearing to be filled more compactly than the center. The most satisfactory plan seemed to be to cut a ditch about eight inches deep for the full width of the road, casting the sand removed back upon the stalks last placed in position. When the cut had extended about six feet from the completed road, it was filled by a new batch of stalks, and these in their turn were covered by sand taken from a new length of road excavation. This road stood well the hard usage given it by Cavalry, Artillery and heavy loads of hay. It was later further improved by spreading over it a layer of loose hay. Thus by very simple means an almost impassable sand bar was turned into a decidedly practical road over which heavy loads passed with ease.

It is remarkable that sign boards, however plain and conspicuous, are not a sufficient guide for troops or wagon trains. The two roads mentioned above were so laid out that both bridges could be used simultaneously by foot and mounted columns without permitting these columns to cross and interfere with each other. No attention appeared to be paid to the signs, and the columns crossed to such an extent that the capacity of the two bridges was reduced to that of one. It is thought that sentinels should be posted at all cross roads or points where roads are near together to require passengers to follow the proper roads.

On October 16–17, the company participated in the maneuvers of Problem 2, forming part of the Blue forces. A copy of this problem *is* enclosed herewith with a copy of my report to the Adjutant General of the First Brigade.

October 22d. The company took part in the deployment of the Division, Problem 5, but was not detached from the Battalion for any purpose, and performed no service other than being present.

October 23d. The company formed part of the Blue forces for Problem 6. Copies of Field Orders No. 1, Headquarters Blue Division, and my report to the Adjutant General of the Blue Division, are submitted herewith. Attention is invited to the fact that the company, starting at the rear of the Infantry of the Division, at the end of the first six miles of the march, had caught up with the support of the advance guard, and then made a reconnoissance over extremely rough ground, covering the first 10 miles of this march in three hours, no allowance being made for halts or delays. The company was absent from camp from eight o'clock in the morning until four o'clock in the afternoon, and covered 22 miles of country. Not a single man fell out or straggled. These facts are mentioned because one of the regiments of Infantry taking part in this problem has been credited with making the most difficult march of all during the maneuvers. Company D marched four miles farther than that regiment, and practically passed completely around it.

October 24th. The company in the Battalion took part in the review of the entire Division.

October 26th. The company acting with the Battalion, participated in the defense of a position, Problem 7, and constructed about 110 feet of kneeling trench and a few rifle pits. This line was not attacked and the mounted section, and later nearly all the company, was sent to assist in the defense of the bridges over the Republican River.

October 29th. The company marched with the Battalion to the Republican Flats and bivouacked. Before daybreak of the following day, it took part in the night attack on the Brown forces. It performed no duty apart from the Battalion.

From October 31st to November 2d. The company furnished details to assist in dismantling the ponton bridges and preparing material for shipment to Fort Leavenworth.

November 3d. The company marched from Fort Riley with the Battalion and arrived at Fort Leavenworth November 11th. One sergeant, one corporal and eight privates returned to Fort Leavenworth by rail acting as a train guard.

During the maneuvers the company consisted of one captain, one second lieutenant and 74 enlisted men. Seventeen enlisted men were mounted.

The light bridge train, which is under the charge of the company, was used only as a supply division, and did not accompany the company on the road. No notes or recommendations regarding it can therefore be made. The personal equipment of the men was constantly studied, and it is believed that it should be improved. The work of the Engineer troops requires them to march to the front to make reconnoissances or to build or repair roads or bridges, and after the troops have passed, the Engineers must dismantle or destroy their work and then regain the head of the column. While they are equipped as Infantry this imposes a heavy strain upon them. It is suggested that light wagons capable of carrying most of their personal burdens, or even of carrying the men themselves, would enable them to meet this demand and retain their strength for the important Engineer work mentioned.

The loose shoulder straps should be discarded. They catch in the brush. Many were completely torn from the blouses. The greatest trouble during hard marching seems to be with the men's feet. It is therefore very important that the shoes issued for field wear should be the very best obtainable. Great care was taken before leaving Fort Leavenworth to see that all the men were provided with shoes in good condition. Of the new shoes used, 21 per cent failed before reaching Fort Riley, and 87 per cent failed on or before the return march. Of the shoes that were not new but in good condition, 54 per cent failed on the way to Fort Riley, and 88 per cent failed before the return to Fort Leavenworth. These shoes cost $2.20 per pair. I am convinced that a shoe can be obtained for not more than $5 per pair that will be much cheaper per mile than those issued, and will be more comfortable because worn longer after breaking in. The shoes should be provided with Hungarian cone-head nails on the soles to give a more secure footing on dry grass or rock. They also protect the soles and at the same time diminish the slipping and wear. In rough country, especially when the grass is burned by the sun, they will increase the endurance of the men fully 25 per cent.

Officers and non-commissioned officers should be provided with compasses with fluorescent dials which can be read in the dark without striking matches.

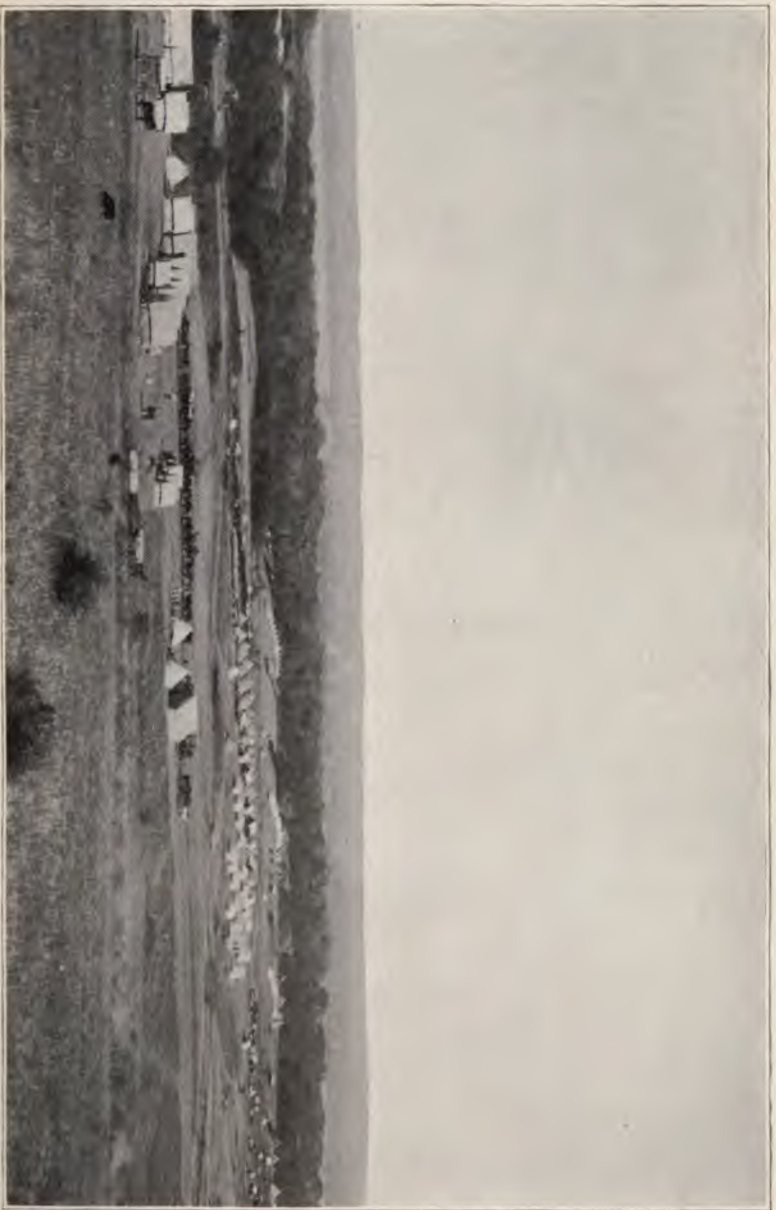
Sabers should be discarded. The first view of distant troops was generally obtained by looking for flashes of light from saber blades. The sabers proved to be great encumbrances, were of no use, and after a few days in the field were not even ornamental. It is suggested that a hollow metal case for maps and drawings would be much more useful for Engineer officers could be made equally ornamental, and like the batons formerly carried by officers of considerable rank, would be useful for signaling or pointing in the field.

The spurs of the mounted men should also be discarded, although they might be permitted to be worn when necessary. They are rarely used, hand to hand fighting mounted being infrequent nowadays, and they are very inconvenient when dismounted in long grass, brush or mud.

A great reduction in the bulk and weight of records may be made by means of a system of card files in place of large books. The records of the company displaced on the company wagon ammunition and supplies that in the field would be of much greater immediate value than the records.

Very respectfully, your obedient servant,

R. R. RAYMOND,
Captain, Corps of Engineers, Commanding Company D.



2D PROBLEM.

October 17th, Saturday.

Outpost and patrolling for all regular troops.

GENERAL IDEA.

A Blue and Brown Division, each having a brigade, of all arms, as advance guard, are approaching each other in the valley of Clarke's and Humbolt Creeks. Each has received information that the enemy is in the front at no great distance, and the two advance guards have halted and established outposts from which more carefully to examine the country in front.

SPECIAL SITUATION.

Blue.

A brigade, of all arms, forming the advance guard of a division advancing to the north and east through Clarke's Creek Valley, has received information of the presence of hostile parties in front. The advance guard establishes an outpost and sends forward information patrols to ascertain conditions.

The Blue force will leave at 3:00 P. M., October 16th, and bivouac on Smoky Hill Flat near the junction of Smoky Hill River and Hays Creek. It will leave bivouac the next morning in advance guard formation and move by Clarke's road to the proper point from which to establish an outpost, with its left resting on Grant Ridge, near Kramer's Ranch, and the right on Clarke's Creek. The outpost will be established by 9:30 A. M., and information patrols, foot and mounted, will be sent to the front to examine the country to the north and east and between Clarke's Creek and Grant Ridge.

All patrols will return to the command by 12 M., when dinner will be eaten and the force will await further orders, which will be given through the Chief Umpire.

OFFICIAL:

C. D. ROBERTS,
Capt., Aid.

Copy respectfully furnished Company D, Engineers.

CAMP WILLIAM CARY SANGER,
FORT RILEY, KANS.,
October 17, 1903.

THE ADJUTANT GENERAL,
FIRST BRIGADE, PROVISIONAL DIVISION.

SIR:

I have the honor to submit the following report of the operations of

Company D, 1st Battalion of Engineers, on October 16th and 17th, 1903, in connnection with the 2d problem.

The company consisted of two officers and 54 enlisted men, of whom 14 were mounted, two were on duty with the company pack train, and one was teamster. One private of the Hospital Corps was also assigned to the company for the occasion.

The company in the field order, accompanied by its pack train loaded with the regular Engineer tool pouches and by one wagon loaded with tools, moved from the camp of the 1st Battalion of Engineers about 3:30 P. M., October 16th, and took its place in the line of march immediately preceded by the Artillery, in order that assistance might be rendered that arm in case of bad roads or other difficulties. The roads had, however, been previously made passable, and no such assistance was needed. The night of the 16th was passed in bivouac on the bank of Hays Creek.

Reveille on the 17th was at 5:30 A. M., and at daybreak the company resumed its march, again immediately preceding the Artillery, for the purpose named above. The roads were in passable condition, and the route after leaving the roads required no preparation for the passage of the Artillery. During the deployment of the brigade, and in the absence of specific instructions, the company was kept in the vicinity of the Field Artillery in the belief that that arm might have need for its services. This indeed proved to be the case; for the 29th Battery was unable, with the tools in its possession, to intrench its guns in the time available, the ground being very stony and the Brown forces being seen advancing at not more than 3,000 yards. The entire company was therefore employed in constructing the necessary gun-pits. This work was successfully completed except for the right gun where the ground was too stony for excavation, and the gun was left upon the natural surface, a parapet being thrown up around it. The company was then assigned by General Grant as support for this battery in order to release the battalion of Infantry originally assigned to that duty, and took up its position behind the hill at the right flank of the battery, sending the tool wagon and all animals to cover in rear. This position was maintained throughout the remainder of the engagement, until recall, when the company returned to camp via Clarke's Creek Road and the Mormon Trail.

Very respectfully, your obedient servant,

R. R. RAYMOND,

Capt., Corps of Engineers, Commanding Company D.

HEADQUARTERS BLUE DIVISION,
PAWNEE FLATS, FORT RILEY, KANS.,
October 22, 1903.

**FIELD ORDERS
NO. 1.**

I. A detachment of the enemy is reported to be in the vicinity of Garrisons, Kans., and is said to consist of all arms.

II. (*a*) A reconnaissance in force toward Garrisons, Kans., will be made tomorrow. A serious entanglement with the enemy is not desired, but a vigorous attack will be made upon him wherever encountered, and will be pushed sufficiently far to drive in his outposts or advance detachments and fully develop his strength and position.

(*b*) The Cavalry, operating under special instructions of the Division Commander, will, in case the enemy is encountered by the main column, push in to attack vigorously, and must secure information even at the cost of a portion of its force.

III. (*a*) The main body and advance guard will proceed from camp at 8:30 A. M., tomorrow, October 23d, and will follow the main road from Ogden to Garrisons, via Keats Postoffice (the road which passes Schoolhouse No. 73.)

(*b*) The Commanding Officers of the 4th Cavalry and of the Engineer detachment will report to the Division Commander for special instructions. The following officers:

Capt. R. R. Raymond, Engineer Corps; Capt. E. B. Winans, jr., 4th Cavalry; 1st Lieut. Guy V. Henry, 4th Cavalry, are detailed as reconnaissance officers, and will likewise report to the Division Commander for special instructions.

(*c*) The regimental field dressing stations accompanied by the necessary Hospital Corps detachments, will follow in rear of their respective commands.

(*d*) The remainder of the medical department and equipment, ambulance companies, etc., together with the sick and convalescent, will be reported to the officer designated to take charge of the wagon train. This officer (to be designated later) will select a strong de-

ORDER OF MARCH.

I. Advance guard: 6th Infantry; Lieut. Col. R. H. R. Loughborough, 6th Infantry, Commanding.

II. Support: 55th Iowa and 25th Infantry, 7th, 28th, 20th and 29th Field Batteries, in the order named.

III. Main Body: 3d Brigade less two companies.

IV. Rear Guard: two companies of the 3d Brigade.

The detachments mentioned above will keep well closed up and follow each other at the minimum distances allowable by the terrain and cover.

fensive position on the top of Sheridan Heights and will park the wagon and hospital trains and the tool train of the Engineers at a suitable place within the limits of this position, which will be placed in condition for defense by the construction of shelter trenches, obstacles, etc. All regimental bands, and such sick in quarters and convalescents as are able to do so, will report to the officer designated to take charge of trains, to assist in the defense thereof.

(*e*) The Signal Corps will maintain communication between the train park and the rear of the command. It will also provide signal men with flags to communicate between the Division Commander and advance bodies.

IV. The commander of the main body will detail two companies to follow the command as a rear guard. Should the command become engaged, these companies will be immediately sent one to the rear of and echeloned on each flank, to guard against surprise.

V. The Division Commander will be found with the support until the enemy is encountered and an engagement develops. Should an engagement take place, he will be found somewhere in the vicinity and in rear of the center of the line, on high ground if available. Those desiring to communicate with him after the engagement begins must look for his flag.

By command of BRIGADIER GENERAL BELL:
MICHAEL J. LENIHAN,
Capt., 25th Infantry, Adjutant General.

Copies furnished Brigade, Regimental, Battalion, Squadron and Battery Commanders.

CAMP WILLIAM CARY SANGER,
FORT RILEY, KANS.,
October 23, 1903.

THE ADJUTANT GENERAL,
BLUE DIVISION.

SIR:

I have the honor to submit the following report of the operations of the dismounted sections of Company D, 1st Battalion of Engineers, in connection with Problem 6.

Information obtained.—Prior to 11:00 o'clock, a Brown battery was in position on the bluff just southeast of Weisman's and Brown Cavalry, dismounted, was deployed on the ridge across the creek from Weisner's. At 11:00 o'clock these forces withdrew toward the northwest, and no Brown troops remained east of the road running north from Schoolhouse No. 73.

Details of reconnaissance.—In pursuance to Field Orders 1, Headquarters Blue Division, October 22, 1903, the company (less the mounted section) moved from camp at 8:30 A. M., and passed Three Mile Creek at 8:35 A. M. This start was timed to avoid waiting in line and to enable the company to make a rapid march to Ogden under cover of the point and flankers of the advance guard. The support of that body was passed at Ogden, and the company proceeded to destroy the two bridges just east of that place. This done, the shelter tents were readjusted upon the men so as to conceal as much as possible of the blue shirts, and the company moved in advance guard formation up the east bank of Seven Mile Creek, sending flankers over to the west bank and up the draws to the east.

From a point about one-half mile south of Kemnitz', the Cavalry and Artillery mentioned above were observed. In order to learn the extent of the Brown line to the eastward, the company moved to Kauer's. From that point a patrol was pushed directly north until about one mile to the east of Eskerson's. No Brown troops were found in this region. Heavy firing was heard to the westward. The company was therefore moved from Kauer's toward the northwest; but before contact with the enemy was obtained, the recall was sounded, and the company returned to camp.

Very respectfully, your obedient servant,

R. R. RAYMOND,
Captain, Corps of Engineers.

REPORTS OF 1ST. LIEUT. STICKLE, CORPS OF ENGINEERS, COMMANDING COMPANY A.

FORT LEAVENWORTH, KANS.,
November 18, 1903.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS,
SIR:

I have the honor to report as follows concerning the operations of Company A from the time of its arrival at Fort Riley, Kansas, October 2d, 1903, till its departure for Fort Leavenworth, November 2d, 1903, including its participation in the maneuvers at that place:

October 2d the company under the command of Lieut. Arthur Williams, Corps of Engineers, except the mounted section, arrived at Fort Riley and made camp.

October 3d the mounted section under my command arrived and joined the company having marched from Fort Crook, Nebraska, and made a map of the road en route. A copy of the report concerning this march, Appendix "A" accompanies this report.

A reserve ponton division had been assigned to A Company and was under the immediate charge of a bridge section consisting of four non-commissioned officers and sixteen privates of the company.

On October 5th a site for two ponton bridges, one wagon and one foot, across the Kansas River at Fort Riley was selected, about one mile south of Division Headquarters, the river flowing northeast at the site. The bridges were located so that the eastern approaches were on a sloping sand-bar; the western bank for the wagon bridge, steep, and 14 feet above the water; for the foot bridge, with a lesser grade, and 8 feet above the water. The site in a general way was selected by the Battalion Commander, and the exact location of the bridges chosen by myself. A graduated gage for deter-

mining elevation of water was firmly set by Lieut. Williams, and remained in place, and readings taken and recorded three times daily until the bridges were dismantled. The north approaches to both bridges were cut down with pick and shovel by an average of 60 men from all the companies of the Battalion on October 5th and 6th. The grade was made one on thirteen and involved the removal of nearly 500 cubic yards of earth. Two slip scrapers were used on October 6th and 7th and part of October 8th.

The wagon bridge was constructed on October 6th by a detail of 10 non-commissioned officers and 74 privates obtained from all the companies in the Battalion. This bridge was 286 feet 8 inches long.

While constructing the bridge a strong cross wind was blowing, so that several chess carriers were blown overboard. All boats were anchored upstream and every other one downstream. One trestle and twelve pontons were used. In addition to the two side rails prescribed, a middle rail was placed over the middle balk, and lashed liked side rails to it. Two chess per bay were properly notched to make room for lashings. The effect was to materially stiffen the balk, but more important, to prevent the ordinarily relatively great differences of elevation of adjacent chess when animals crossed the bridge, and third to prevent the slipping of the chess at right angles to the bridge. It was not in the way for any traffic, the ends of rack sticks, where necessary, being lashed to the middle rail.

The first method of constructing the abutment bay given in fig. 2, Plat XII, U. S. Bridge Equipage, was used, contact between balks and gunwales being provided or when necessary by wooden wedges driven in, and changed as necessary in case of rise and fall of pontons.

On October 7th the water having risen seven feet the trestle at the east end of bridge, was replaced by a ponton and the trestle carried toward the shore, increasing the length of bridge to 307 feet 4 inches. It remained this length until the bridge was dismantled.

The bridge section's sole duty during the month of October was to keep this bridge, and the foot bridge (constructed later) in order for the passage of troops and vehicles at all times. From the bridge section and the remainder of the dismounted section of the company, a guard was established October 15th and was continued throughout the month. A copy of Special Orders for guard and sentinels is appended (Appendix "B").

On October 7th the eastern approach to the bridge was improved by utilizing thirteen loads of rock, hauled from the Fort Riley quarry.

Some of this rock was used in making a low wall on the upstream side of this approach. The roadway was completed by scraping in gravel and coarse sand. The bridge without change was then practicable up to a three-foot rise.

On October 15th with 28 men from A Company and details from the other companies to make a total of 84 non-commissioned officers and men, constructed a foot bridge about 125 feet below the wagon bridge. The bridge was constructed with extended intervals, all bays reinforced. Ten boats and one trestle were used and the total length of bridge was 294 feet 8 inches. The western approach was readily made practicable for foot troops. Advance guard side rails had to be used and mostly advance guard chess, for this bridge. On October 19th the wagon bridge was covered with a layer of hay, mainly to protect the chess, this it did satisfactorily. It was necessary to replace it frequently as the continual traffic over this bridge rapidly pulverized it. The objection to the hay is that it makes it more difficult to observe promptly, cracked and broken chess, but it did excellent service and it is probable that without it a large number of the chess would have broken under traffic during the month.

As mounted troops were allowed to cross mounted, and foot troops well closed up, considerable oscillation was observed in the bridges, especially the wagon bridge.

On October 20th cables were passed along the wagon bridge under roadway from bow of one boat to stern of next and so on, the ends of cables being firmly attached to posts on the shores. The cables leading from the same end of a boat were in each case surrounded by a sling some six feet from point of attachment and cables rendered taut by turning a rack stick sufficiently and lashing it to one of the cables. In this way a sort of horizontal truss was formed. This lengthened the time of oscillation and reduced the extent of oscillation and improved the working of the bridge under such loads as mounted troops and loaded pack mules. It it is not believed advisable for cables, slings and rack sticks to be especially provided for stiffening in this way, as usually it takes too much time to put on for a very temporary bridge, cavalry may be required to dismount, and special precautions should be taken. Again for a bridge which is to be used for some time, cables, etc., may be obtained in exactly the same way as was done in this case, and be put on after the bridge has been used for some time. This method was suggested by Lieut. Williams.

On October 21st, the same method of stiffening was applied to the foot bridge.

On October 22d, Lieut. Williams with the mounted section took part in the problem for the day.

On October 23d, six non-commissioned officers and seventeen privates were directed to report to Captain Deakyne for duty in the construction of trenches.

On October 24th, the entire division crossed the ponton bridges for review and returned. My report on that date is appended (Appendix "C").

On October 26th, in the problem of "Attack and defense of position" Lieut. Williams with the mounted section accompanied the Battalion. The dismounted section of the company (except bridge section) were posted to protect the ponton bridges as part of the Blue force. My report of the operations of the dismounted section is appended (Appendix "D").

October 27th, in the field sports of the division, Company A was limited to three entries. In the three entries the company representing the Battalion won prizes as follows:

1. Team under Corporal Fitton, pitching of conical wall tent, first prize.
2. First class private Watson, equipment race, first prize.

October 29th, the mounted section under Lieut. Williams, took part in the exercise as part of Battalion going into bivouac for the night returning at 9:00 A. M., October 30th. The foot bridge was dismantled and material piled in two hours and two minutes under my direction by six non-commissioned officers and nineteen privates of the company.

On October 31st, the company with enough men from other companies to make 84 non-commissioned officers and men dismantled the wagon bridge and piled material in one hour and thirty-five minutes.

October 30th and 31st, and November 1st, the bridge section hauled boats from water and loaded wagons as rapidly as wagons were made available.

On November 1st, the company assisted in loading ponton material on train.

On November 2d, the company broke camp and went into shelter tents, and on November 3d, at 9:40 A. M., the company left Fort Riley for Fort Leavenworth by marching with the Battalion.

Record of gage during the month of October.

October 5, 1:30 P. M., 2.0 feet.
October 5, 6:30 P. M., 2.0 feet.
October 5, 7:30 A. M., 2.0 feet.
October 6, 7:30 A. M., 2.0 feet.
October 6, 1:30 P. M., 2.0 feet.
October 6, 6:30 P. M., 2.0 feet.
October 7, 7:30 A. M., 2.0 feet.
October 7, 1:30 P. M., 2.7 feet.
October 7, 6:30 P. M., 2.5 feet.
October 8, 7:30 A. M., 2.1 feet.
October 8, 1:30 P. M., 2.1 feet.
October 8, 6:30 P. M., 2.0 feet.
October 9, 7:30 A. M., 2.0 feet.
October 9, 1:30 P. M., 2.0 feet.
October 9, 6:30 P. M., 2.0 feet.
October 10, 7:30 A. M., 1.9 feet.
October 10, 1:30 P. M., 1.9 feet.
October 10, 6:30 P. M., 1.9 feet.
October 11, 7:30 A. M., 1.9 feet.
October 11, 1:30 P. M., 1.9 feet.
October 11, 6:30 P. M., 1.9 feet.
October 12, 7:30 A. M., 1.9 feet.
October 12, 1:30 P. M., 1.9 feet.
October 12, 6:30 P. M., 2.0 feet.
October 13, 7:30 A. M., 2.0 feet.
October 13, 1:30 A. M., 2.0 feet.
October 13, 6:30 P. M., 2.0 feet.
October 14, 7:30 A. M., 2.1 feet.
October 14, 1:30 P. M., 2.1 feet.
October 14, 6:30 P. M., 2.1 feet.
October 15, 7:30 A. M., 2.1 feet.
October 15, 1:30 P. M., 2.1 feet.
October 15, 6:30 P. M., 2.2 feet.
October 16, 7:30 A. M., 2.2 feet.
October 16, 1:30 P. M., 2.2 feet.
October 16, 6.30 P. M., 2.2 feet.
October 17, 7:30 A. M., 2.2 feet.
October 17, 1:30 P. M., 2.2 feet.

October 17, 6:30 P. M., 2.2 feet.
October 18, 7:30 A. M., 2.2 feet.
October 18, 1:30 P. M., 2.2 feet.
October 18, 6:30 P. M., 2.2 feet.
October 19, 7:30 A. M., 2.1 feet.
October 19, 1:30 P. M., 2.1 feet.
October 19, 6:30 P. M., 2.1 feet.
October 20, 7:30 A. M., 2.1 feet.
October 20, 1:30 P. M., 2.1 feet.
October 20, 6:30 P. M., 2.1 feet.
October 21, 7:30 A. M., 2.1 feet.
October 21, 1:30 P. M., 2.1 feet.
October 21, 6:30 P. M., 2.1 feet.
October 22, 7:30 A. M., 2.1 feet.
October 22, 1:30 P. M., 2.1 feet.
October 22, 6:30 P. M., 2.0 feet.
October 23, 7:30 A. M., 2.0 feet.
October 23, 1:30 P. M., 2.0 feet.
October 23, 6:30 P. M., 2.0 feet.
October 24, 7:30 A. M., 2.0 feet.
October 24, 1:30 P. M., 2.0 feet.
October 24, 6:30 P. M., 2.1 feet.
October 25, 7:30 A. M., 1.9 feet.
October 25, 1:30 P. M., 1.9 feet.
October 25, 6:30 P. M., 1.9 feet.
October 26, 7:30 A. M., 1.9 feet.
October 26, 1:30 P. M., 1.9 feet.
October 26, 6:30 P. M., 1.9 feet.
October 27, 7:30 A. M., 1.9 feet.
October 27, 1:30 P. M., 1.9 feet.
October 27, 6:30 P. M., 1.9 feet.
October 28, 7:30 A. M., 1.9 feet.
October 28, 1:30 P. M., 1.9 feet.
October 28, 6:30 P. M., 1.9 feet.
October 29, 7:30 A. M., 1.9 feet.
October 29, 1:30 P. M., 1.9 feet.
October 29, 6:30 P. M., 1.9 feet.
October 30, 7:30 A. M., 1.9 feet.
October 30, 1:30 P. M., 1.9 feet.

October 30, 6:30 P. M., 1.9 feet.

October 31, 7:30 A. M., 2.0 feet.

Soundings every ten feet were taken at each bridge and recorded. The deepest water at the wagon bridge was 6 feet 4¼ inches with the gage at 2 feet.

With the exception of October 7th the two boats at the western end of the bridge were aground at all times, while with a less reading than 2.0 feet three were aground.

The deepest water at the foot bridge was 6 feet ¾ inches with the gage at 2.0 feet.

One boat was aground at all times at the western end of the bridge while with a reading less than 2.0 feet, two were aground.

The following is the record of the crossings of the bridges from October 16th to October 30th:

Foot Bridge.

Twenty-five regiments of infantry, 2 companies of infantry, 3,222 footmen (mostly civilians), 5 light wagons, 2 pack trains, and the mounts accompanying foot troops also crossed the bridge.

Wagon Bridge.

Twenty-three regiments of infantry, 44 companies of infantry, 121 troops of cavalry, 38 batteries of artillery, 16 mounted sections of engineers, 6 dismounted sections, 1,727 individual horsemen, 206 one-horse vehicles, 751 footmen, 703 two-horse vehicles, 386 four-mule wagons, 73 six-mule wagons, 4 pack trains, 214 loads of hay, 1 automobile, 2 Colts automatic R. F. guns.

The mean surface velocity of the river at reading 1.9 was found to be 2.3 miles per hour.

The bridge material consisted of one division complete (except for certain shortages) from Washington, D. C., the balance from the 1st Battalion of Engineers, Fort Leavenworth. It was all in very good condition, not one balk broke under the heaviest loads, and only eight chess were replaced in the bridges. No accident of any kind occured on the bridges.

The foot bridge reinforced as it was, could have been safely used if necessary for any ordinary army traffic.

Remarks.

It is recommended that enough balk be furnished with each division for putting a middle rail on all bridges built for passage of animals.

It is believed that the chess should be one-fourth inch thicker than at present.

This recommendation concerning balk and chess is made, notwithstanding that it would probably require extra wagons for transportation.

A skiff should be furnished with each division to be manned during crossings and for use in making close inspection of balk, and for many other purposes.

The work of Sergeant William McNally in charge of the bridge section was well and intelligently performed and his services are particularly recommended.

Lieut. N. E. Bower joined the company from detached service at West Point, Kentucky, on October 17th and was placed on special duty under the Chief Umpire on October 18th, and remained on special duty to include November 2d.

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers.

APPENDIX A.

CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,
October 27, 1903.

THE ADJUTANT GENERAL,
DEPARTMENT OF THE MISSOURI,
Omaha, Nebr.
(Thro' Military Channels.)

SIR:

I have the honor to report the execution of par. 2, Special Orders No. 178, c. s. Headquarters, Department of the Missouri.

The order was received September 14th. Preparations were at once made to provide my detachment with the necessary equipment and the Quartermaster, Fort Leavenworth, was requested to furnish transportation on September 16th. In order to properly care for the animals I secured a coach for the detachment on the same freight train with them. The baggage, engineer equipment, and animals were loaded on the afternoon of September 16th. The detachment consisted of the mounted section of Company A, 1st Battalion of Engineers, two packers from that company and the necessary mounts for section, two riding mules for packers, and six pack mules.

The train left Fort Leavenworth at 8:30 P. M., September 16th, over the Missouri Pacific R. R. and arrived at Fort Crook about 5:00 P.M., September 17th.

Five hours were lost at Nebraska City, Neb., due to the fact that our engine while switching was derailed and the railroad company seemed unable to get it back on the track. The efforts of the company being unproductive of results, and having been delayed from about 7:15 A. M., to 12:30 P. M., I wired the circumstances to the Chief Quartermaster of the Department, and an engine arrived and the train started within fifteen minutes. The animals were in box cars and there were no facilities for watering or feeding them.

I reported immediately to the Commanding Officer, Fort Crook. The Quartermaster, Fort Crook, informed me that he had five wagons to be taken to Fort Riley, but that he had no teamsters and no authority to hire them. He also stated that he had no Quartermaster's funds for the purchase of regular supplies, and the making of necessary repairs en route to Fort Riley.

On September 18th, I proceeded to Omaha and reported to the Chief Quartermaster of the Department, who obtained authority and transferred to me the necessary funds and telegraphed to the Quartermaster General U.S. Army, for authority to hire five teamsters. Rations and such forage as could be carried were obtained the same day.

On September 19th, the authority was obtained, and efforts made to hire five teamsters. Three were secured, and on September 20th, the detachment started on its march to Fort Riley, two men of the mounted section being utilized as teamsters. One teamster was hired at Meadow, September 24th, and one at Firth, September 27th.

Having been informed that no road bridge existed across the Platte below Fremont, some fifty miles out of my way, I telegraphed the Chief Quartermaster of the Department from Springfield, Neb., for transportation for my detachment from Meadow to South Bend, Neb., via the C. R. I. and Pacific R. R., such transportation to be used if necessary.

Upon arriving at Meadow, September 21st, I found the road bridge out, and the river impossible to ford. At about 9:30 A. M., the agent at Meadow informed me that he had instructions to transport my detachment to South Bend, and before noon of the same date I had information from the Chief Quartermaster of the Department to the same effect.

The necessary cars were not then at hand and transportation was not furnished until 12:15 P. M., September 24th, notwithstanding that every effort was made by me to get transportation, and I telegraphed daily to the Chief Quartermaster of the Department concerning it.

The detachment was detrained at South Bend by 4:00 P. M., same date.

Corporal Philgren was taken sick at Meadow and was sent by direction of the Commanding General to the Hospital at Fort Crook, on September 23d.

On September 25th the detachment started from South Bend, to Fort Riley arriving there without further delay about 2:00 P. M., October 3d.

I reported to the Commanding General, and, the 1st Battalion of Engineers having already arrived, I and my detachment joined that command.

The transportation escorted by my detachment from Fort Crook was turned over to Captain Chauncey B. Baker, Quartermaster, U.S. Army.

The detachment and all animals arrived in excellent condition, the march from South Bend, Neb., to the Headquarters, Provisional Division, Fort Riley Reservation, a distance of 175.9 miles being marched in nine successive days or an average of 19.5 miles per day.

The distance was determined by timing of horses checked by two odometers. The distance determined by timing from Fort Crook gate to the Headquarters, Provisional Division, Fort Riley Reservation is 202.8 miles. The distance determined by odometers is 200.63 miles, being a difference of 2.17 miles for the entire distance.

The odometers were on the front wheels of the same wagon, the wheels having the same measured circumference. Ordinarily the odometer checked well but when the road was rough, sandy, or muddy, considerable variation in the records of the two occured. The odometers were used as a check only, and it is believed that 202.8 miles for the distance is very close to correct.

About ten miles were lost covering distances east and west more than once. Such lost distances were short, and in such long distance it is impracticable to avoid all of them.

It was intended to sketch two side roads the entire distance with occasional crossroads, and this was done whenever practicable. Three stopwatches only were to be obtained for my sketching details. These were supplemented by personal watches, but the usage given to all watches was hard and many personal watches and one stopwatch were soon out of order. It was considered impracticable to delay the march till others could be obtained. The number of roads practicable near Fort Riley was more limited, and the side work was therefore necessarily diminished in amount.

Sketches were compiled on a drawing board as soon as practicable after the detachment went into camp each evening.

The work of the men of the detachment was faithful and their bearing excellent.

Since arrival at Fort Riley the sketch has been reduced, traced, and blue prints made. This work has been necessarily delayed by participation in the maneuvers and for other reasons.

A Road Report with two sets of blue prints, six per set, accompanies this report.

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers.

APPENDIX B.

COMPANY A, 1ST BATTALION OF ENGINEERS,
FORT RILEY, KANS.,
October 14, 1903.

During the maneuvers or until otherwise ordered the following is directed for the bridge guard:

The guard will consist of one non-commissioned officer and six (6) privates. It will be mounted daily at 6:00 P. M., and be on duty for twenty-four (24) hours.

Two posts will be established.

The post of No. 1 extends from the west end of the park, along the north side of the wagons to the north approach of the wagon bridge, south on the north approach to the wagon bridge, and the wagon bridge.

No loose horses or cattle will be allowed on the bridge.

Care will be taken to see that no team, or horse, be permitted to come upon the bridge for crossing while another is crossing in the opposite direction. All teams and animals will be required to cross at a walk.

The post of No. 2 extends from the north approach of the wagon bridge east to north approach of foot bridge, and south on north approach to foot bridge, and foot bridge. No. 2 will allow no animals of any kind except mounts accompanying foot troops to cross the foot bridge.

Orders for both sentinels:

The sentinels will allow no enlisted men or civilians to loiter on the bridge. They will watch carefully for drift or other danger to bridges, and report to the non-commissioned officer of the guard, when either bridge is in danger from any cause.

Sentinels will render the customary salutes of sentinels.

Sentinels will halt troops crossing the bridges if violent oscillations are observed, until the oscillations cease.

A sentinel may leave his post to call the guard, and when directed by the non-commissioned officer of the guard, but not otherwise.

The equipment of sentinels is the revolver, belt, and five rounds revolver ball catridges.

Sentinels will keep a record of organizations, detachments, and individuals crossing the bridges, with times of crossing, as nearly as practicable. Memorandum books will be provided for this purpose.

During the crossing of troops mounted or otherwise, the members of the guard will place themselves, under the supervision of the non-commissioned officer of the guard in the most suitable places to watch the bridge and render assistance in case of accident. Dismounted troops will be required to pass in column of twos at broken step.

Cavalry should remain mounted and Artillery should cross with as little interval as possible. The guard will visit camp for its meals leaving one man in the guard tent in addition to the sentinel on post.

The cables will be tightened when dry after a rain.

When it is known that a body of troops are soon to cross the bridges the commander of the guard will notify at once the senior non-commissioned officer of the bridge section who will, if possible be present with his section at such crossings. Lashings, cables, chess, etc., will be carefully inspected daily, and after each crossing of troops and anything out of order will be at once repaired.

The commander of the guard will keep careful watch of the tide gage, or see that it is done by a member of his guard. In case the reading should be 2 feet or more he will notify the senior non-commissioned officer of the bridge section who will at once turn out with his section. In case reading should be 3 feet or more the Company Commander will be notified.

H. W. STICKLE,
1st Lieut., Corps of Engineers,
Commanding Company.

APPENDIX C.

FORT RILEY RESERVATION, KANS.,
October 24, 1903.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS.

SIR:

In accordance with verbal instructions from the Battalion Commander, I have the honor to report as follows concerning the crossing this date, of the Kansas River twice by the Provisional Division, on two ponton bridges, built by Company A, 1st Battalion of Engineers:

1st crossing (from west to east.)

1. Lower bridge.

One brigade of Infantry crossed 7:50 A. M. to 8:01 A. M.

2. Upper bridge.

1st Battailon of Engineers crossed 7:53 A. M. to 7:56 A. M.

Signal Corps Battalion crossed 7:56 A. M. to 7:57 A. M.

Three Brigades of Infantry crossed 7:57 A. M. to 8:31 A. M.

Divisional Artillery crossed 8:31 A. M. to 8:48 A. M.

Cavalry Brigade crossed 8:48 A. M. to 9:15 A. M.

Detachment of Field Hospital and ambulance companies crossed 9:15 A. M. to 9:20 A. M.

Wagon train, about 120 wagons crossed 9:20 A. M. to 9:56 A. M.

Pack trains crossed 9:56 A. M. to 9:59 A. M.

From 9:33 A. M. to 9:36 A. M., upper bridge was closed while a broken chess was replaced and side rail lashings were adjusted.

Lower bridge used: 11 minutes.

Upper bridge used: 2 hours, 3 minutes.

2d crossing (from east to west.)

1. Lower bridge in use for Infantry, 11:36 A. M. to 11:41 A. M.; 12:08 P. M. to 12:11 P. M.; and for pack trains, 1:00 P. M. to 1:02 P. M.; 1:07 P. M. to 1:10 P. M.

2. Upper bridge in use for Infantry, 11:27 A .M. to 11:37 A .M.; 11:41 A. M. to 12:08 P .M.

In use for Artillery, 12:08 P. M. to 12:24 P. M.

In use for Cavalry, Hospital detachments and ambulance companies, 12:24 P. M. to 12:54 P. M.

In use for wagons and Division wagon train, 12:54 P. M. to 1:20 P. M.

No time was lost for repairing bridges during this crossing.

Time lower bridge used: 13 minutes.

Time upper bridge used: 1 hour 53 minutes.

Considering the command in single column in both cases there was a gain in time in the second crossing over the first of eight minutes. No civilians were considered in this report.

Infantry crossed upper bridge in colmn of twos. Cavalry cressed mounted in column of twos.

Infantry,Cavalry and Artillery in crossing were well closed up. Between the first and second crossings, five cracked chess were replaced, new hay placed on upper bridge, and all cables and lashings adjusted.

Counting both crossings between 7:53 A. M., and 1:20 P. M., about 25,000 crossed the bridges exclusive of animals, wagons, carriages, and Artillery pieces and caissons.

The capacity of the two bridges during this time is about 43,000 troops, with the same percentage of various arms with equipment and baggage as took part in the review this date, or 4,000 per bridge per hour.

Very respectfully,

H. W. STICKLE,

1st Lieut., Corps of Engineers.

APPENDIX D.

CAMP WILLIAM CARY SANGER,
FORT RILEY RESERVATION, KANS.,
October 26, 1903.

THE ADJUTANT GENERAL,
BLUE FORCE.
(Thro' Military Channels.)

SIR:

I have the honor to report as follows concerning the operations of the dismounted section of Company A, 1st Battalion of Engineers this date:

The dismounted section consisted of a ponton bridge section of two non-commissioned officers and eleven privates, a bridge guard of one non-commissioned officer and six men, and a section used as infantry of four non-commissioned officers and ten privates.

The bridge section was unarmed and kept the bridge in order, and acted as messengers and observers, reporting promptly during the attack on the bridge any movements of the enemy seen, numbers, etc.

The ponton bridge guard had charge of the bridge crossings and assisted in guarding it against attacks.

The Infantry section was divided into three parts, one non-commissioned officer and two privates were sent to the hill southeast of Whiskey Lake to observe and report if enemy were seen to the east or south, one non-commissioned officer and three privates were left in the trenches constructed on Smoky Hill Flats, and two non-commissioned officers and five privates placed as a picket in the woods at the narrowest places between Whiskey Lake and the Kansas River, about 1000 yards below the bridges, guarding against approach of the enemy from the north.

My instructions had been to guard the eastern approaches to the ponton bridges with the assurance that no attention was required on the Fort side, as it would be taken care of by other portions of the Blue force.

In case of a strong force approaching on the eastern side, I had planned to delay them sufficiently to partially dismantle the bridges, the upper one constructively and the lower one actually.

I remained near the bridge on the western bank, to take charge of this work if it became necessary.

No attention was paid to an attack from this direction as above stated.

I was surprised about 12:20 P. M., by Corporal Boehr, Brown force, and two privates of Troop D, 8th Cavalry, and about 12:40 P. M., Sergeant McNally, unarmed, and myself were captured by two of them, one of Corporal Boehr's men having disappeared. In less than a minute three members of the bridge guard covered Corporal Boehr and his remaining man at less than five yards, and I considered the Sergeant and myself recaptured, or in reality the capture had not been completed. The Corporal and his man were captured and my outposts at once sent for.

The first squad arrived about 12:50 P. M., and the others shortly after.

The men were immediately placed in position behind the river bank and in the wagon cut, and about 12:55 P. M., a squad of from 8 to 12, probably of Troop D, 8th Cavalry, of the Browns, opened fire on our position from about 400 yards above the bridges on the west bank. We were completely sheltered and their fire could have done us no harm. My detachment replied spiritedly and remained in position.

Firing continued till 1:25 P. M., on both sides and the squad of

Browns approached to within about 150 yards from our position, coming in from our front under a strong fire.

At 1:25 the Browns withdrew and at 1:35 P. M., seeing the troops returning, I marched the dismounted section to camp and dismissed it.

Corporal Boehr with his man undoubtedly had me at a disadvantage when I had but two armed men within a half mile, sentries on the bridge. He did not carry out the requirements of par. 22, Circular No. 1 of the Provisional Division, in making his capture. He stated that he had instructions to attach a sign to one of the bridges that it had been destroyed by a Brown force, and when I asked him how he had intended to destroy the bridges, he said he had a knife and might have gotten an axe if any were there, and could have cut the cables, or required us to cut them. He claimed that the mere presence of his three men in the vicinity of the bridge constituted a constructive destruction of the bridges by his method. In the first place his method would not have destroyed the bridges, as both would still have been perfectly passable for any crossing, and in the second, two armed sentries were on the bridges, nine unarmed men of the bridge section at the upper bridge and some time would have been required to do even this with a knife, and axes not in his possession. His bearing throughout was excellent and soldierly, and he endeavored to carry out his orders as far as he understood instructions. I took care to allow him every opportunity to carry forward the advantages he had secured.

It appears that constructive destruction is a privilege which might be easily abused. A sufficient force to overcome all opposition present, with materials required to destroy, and the knowledge necessary to use the materials in actual destruction, and the time necessary to actually do it, should be insisted upon.

No Brown force developed east of the river.

The fact that a Brown troop of Cavalry had crossed the river from Junction City on a street car, and an attack on my detachment was expected, was reported by wire to the Commander of the Blue force at about 12:45 P. M.

No Umpire was in sight during the day.

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers.

U. S. Engineer School
Occasional Papers

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No. 6.

REPORT

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UPON THE OPERATIONS OF THE 1ST BATTALION OF ENGINEERS

IN CONNECTION WITH

THE MANEUVERS AT FORT RILEY, KANSAS, SEPTEMBER AND OCTOBER, 1902,

SMITH S. LEACH,
MAJOR, CORPS OF ENGINEERS, U. S. ARMY, COMMANDING.

PRESS OF THE ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.
—1903—

No.

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REPORT OF MAJOR SMITH S. LEACH, CORPS OF ENGINEERS, U. S. A., COMMANDING 1ST BATTALION OF ENGINEERS.

HEADQUARTERS, 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS,
MARCH 26, 1903.

BRIGADIER GENERAL GEORGE L. GILLESPIE,
CHIEF OF ENGINEERS, U. S. ARMY,
WASHINGTON, D. C.
(Through Military Channels.)

GENERAL:

1. Referring to Department Letter of September 23, 1902, No. 44257, I have the honor to submit a report upon the participation of the 1st Battalion of Engineers in the maneuvers at Fort Riley during September and October of last year. This report contains, either in its body or in the form of appendices, copies of all reports I have submitted in regard to the maneuvers and also of all reports I have received on the same subject from my own subordinates. This report and its appended documents is designed to place in the possession of the Chief of Engineers the fullest information obtainable as to the class of duties and responsibilities placed upon engineer officers and troops during the maneuvers at Fort Riley and on the march thither from this post and return; as to how the new equipment and material fulfilled the purposes for which they were designed, and as to the additional equipment which should be prepared or purchased with funds now, or to become, available.

2. The participation of the battalion in the Fort Riley maneuvers was required by General Orders No. 96, Adjutant General's Office, 1902. General Order No. 34, Headquarters, Department of the Missouri, 1902, provided that "The troops from Fort Leavenworth will proceed by march-

ing, and all riding animals and wagon transportation not essential for post needs will be taken with the commands. Ponton material and heavy baggage, including clothing, wall tents and conical wall tents, in excess of what can be conveniently carried in wagons will be shipped by rail. These commands will reach Fort Riley on or about September 20, 1902." In General Orders No. 38, Fort Leavenworth, Kansas, September 3, 1902, the battalion was ordered to proceed by marching to Fort Riley, Kansas, on September 8, 1902. A contract surgeon, one non-commissioned officer and four privates of the Hospital Corps were assigned to duty with the battalion for the march.

3. General Order, Headquarters, Department of the Missouri, No. 34, afore stated, provided further: "Marches will be conducted as if in the enemy's country, and instructions and exercises given in all the ordinary measures for the safety of the command, such as advance and rear guards, patrols, flankers, and at night outposts, etc. An itinerary and map of the route travelled will be prepared by a competent officer and submitted to these headquarters."

4. The details of breaking camp, forming for the march, etc., were covered by Battalion General Order No. 74, dated September 5, 1902, as follows:

HEADQUARTERS, 1ST BATTALION OF ENGINEERS,
CAMP LUDLOW, FORT LEAVENWORTH, KANSAS,
SEPTEMBER 5, 1902.

GENERAL ORDERS NO. 74.

The following instructions are published for the information and guidance of Company Commanders in carrying out the provisions of General Order No. 34, c. s., Department of the Missouri, and General Order No. 38, c. s., Post of Fort Leavenworth, Kansas.

1. On Monday, the 8th inst., calls will be sounded as follows:

Reveille, 5.15 A. M.; assembly	5.30 A. M.
Mess call	5.45 A. M.
The general	6.15 A. M.

Formation of the battalion for the march:

First call, 9.30 A. M.; assembly	9.40 A. M.
Adjutant's call	9.45 A. M

Upon the sounding of "The General" tents will be struck. All tents to be shipped by rail will be folded and packed for shipment, and hauled to the depot for loading. Immediately upon the return of the wagons, they will be loaded, and the companies prepared for the march.

2. The uniform for the march will be: Campaign hat, khaki coat and trousers, leggins, tan shoes and blue shirt. Each mounted man will carry carbine in scabbard; revolver in holster on belt; canteen, tin cup,

nose bag and lariat, attached to saddles; blanket roll containing shelter tent half, pole and pins, one or two blankets, two towels; in saddle bags, one suit underwear, one pair socks, one chambray shirt, mess kit, soap, comb and brush, tooth brush, curry comb and brush; and one poncho to be carried as desired; pipes, tobacco, etc., if desired.

Each foot soldier will carry carbine and belt; canteen; tin cup attached to belt; blanket roll containing one or two blankets, one shelter half, pole and pins, two towels, one suit underwear, one pair socks, one chambray shirt; haversack containing mess kit, soap, comb and brush; poncho to be carried as desired; pipes, tobacco, etc., if desired.

Color sergeants, equipment of foot soldier, substituting color and sling for carbine.

Each company will carry 100 rounds ball carbine ammunition and 20 rounds ball revolver ammunition; this ammunition will be kept by first sergeant and issued to members of the guard as required.

3. Each man will prepare for shipment the following articles: One suit khaki (coat and trousers), one suit blue (coat and trousers), one extra pair shoes, one pair white gloves, two or three suits of underwear, two or three pairs socks, two or three shirts (chambray or blue). Such men as have sweaters may ship them.

These articles will be prepared for shipment, and hauled to the levee storehouse to-morrow (Saturday afternoon) before four o'clock.

4. Company Commanders will send in to the Post Adjutant with their morning report on Sunday, one ration return for 6 days from and including the 8th and one ration return for 6 days from and including the 14th. On the first will be noted that 1 days' soft bread, 5 days' hard bread and 3 days' bacon are desired, and 1 days' fresh beef to be drawn Monday morning; on the second will be noted that 2 days' flour, 4 days' hard bread, and 2 days' bacon are desired.

Fresh beef will be shipped to the following places:

Winchester, September 10th; Kilmer, 12th; Topeka, 13th; St. Mary's, 15th; Wamego, 16th; Eureka Lake, 18th. The first 6 days' rations will be drawn on Sunday; the second 6 days' rations will be received by rail at Topeka.

Each company will be equipped with two Buzzacott field ovens; and will carry in company wagon two wall tents and one conical tent with sibley stove. An additional conical tent may be carried if transportation is available.

5. In addition to the sick and the post extra and special duty men, the following men of the battalion will be left behind: Sergeant Costello, Company "A" on special duty in Dept. of Eng'ing, G. S. and Staff College.

For guard at Camp Ludlow:
Corporal Murphy, Company "A,"
Private Cluckauf, Company "B,"
Private Royce, Company "C,"
Private Stone, Company "D."

For guard at barracks:
Private King, Company "A,"

Private Geiser, Company "C."
For gardeners:
Private Ernst, Company "A,"
Private Ingle, Company "B,"
Private Martin, Company "C,"
Private Mitchkie, Company "D."

6. Lieutenant H. Burgess, Corps of Engineers, Adjutant, will, in addition to his other duties perform the duties of Battalion Quartermaster and Commissary.

Lieutenant N. E. Bower, Corps of Engineers, is detailed as topographical officer.

Q. M. Sergeant Peter W. Way, Company B, will act as Battalion Q. M. Sergeant.

7. The daily order of march will be:

First.—A mounted detachment as advance guard and reconnoissance party.

Second.—The battalion of unmounted companies.

Third.—The bridge, wagon and pack trains, escorted by a mounted detachment.

Fourth.—A mounted detachment as rear guard, provost guard and reconnoissance party. The commanding officer of this detachment is especially charged to see that all camping grounds are left in proper condition, and that no damage is done to private property on the march. He will immediately report to the Battalion Commander by courier any circumstance which, in his opinion, might give rise to a claim against the United States.

8. The mounted detachments will rotate alphabetically in the three positions described in the preceding paragraph, beginning with the mounted detachment of Company "A" in advance, of Company "B" as rear guard, and of Company "D" as train guard.

The train guard for each day will furnish orderlies for the Battalion Commander and Adjutant, couriers and special details of mounted men not otherwise provided for. Its commanding officer will immediately notify the Battalion Commander by courier in case of any delay to the trains.

BY ORDER OF MAJOR LEACH:
H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant.

The column was formed as indicated in the order and put in march at the time stated. On making first camp the requirements of the Department Order as to security and information were met by the establishment of two mounted pickets on the roads leading to camp, which were placed by the advance guard before the battalion left the road. These were relieved at two hour intervals from the section which had acted as advance guard, until 6 P. M., at which time a guard was posted as provided by the following memorandum:

MEMORANDUM.

There will be a running guard of four non-commissioned officers and eight privates from each company. Company A behind Headquarters, Company B in road, Company C behind wagons. Men to sleep in their companies, and to be turned out for 1½ hour tours. Non-commissioned officers to take two tours of 1½ hours each.

Company D to furnish same detail, to be divided into two pickets of two non-commissioned officers and four privates. Posted on road in advance, and in rear, about ½ mile from camp and to be on from 6.00 P. M. to 6.00 A. M. Non-commissioned officers and privates divide up the time.

The senior non-commissioned officer of each company will report to Captain Flagler, Officer of the Day. The stable guard will be furnished by the mounted detachments.

BY ORDER OF MAJOR LEACH:
H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant.

5. At the close of the second day's march it became evident that the pack train was a troublesome element in the position first assigned to it in the column, and the next morning it was placed in the rear of the bridge train with only the rear guard behind it. The experiences of these two days' march were embodied in the following memorandum dated September 9, 1902:

MEMORANDUM:

1. Hereafter as soon as shelter tents are pitched four men from each company will report to Sergeant Dolan to dig sinks; four men from each company as heretofore ordered, to report to Sergeant Hurtt for Headquarters. This detachment will also provide wood and water for Headquarters, but will not cut wood, etc.

2. Lieutenant Bower—when A Company detachment is with train—will turn over detachment to senior sergeant and will take command of B Company detachment as the advance guard.

3. The detachment which is acting as train guard will ride at head of train of company wagons; but will keep four men at the rear of the foot command, one of whom will remain at any cross road passed to indicate to wagon train which way to go. Any men so left, may rejoin the foot command when the foot command is halted. The detachment acting as train guard will confine itself to the company and battalion wagons.

4. The advance guard will start out in the morning, as soon as the battalion is formed for the march; the wagon train will start 20 minutes after the foot troops; and the pack train 20 minutes after the wagon train. Company and battalion ration wagons will be at the head of the column of wagons. Company tool wagons will follow.

5. Upon arrival at camp the ration wagons will draw up at site of kitchen; Headquarters wagon at site of Headquarters, to stop where directed by the Sergeant-Major; tool wagons will park with bridge train.

unless a company commander desires his wagon at site of kitchen.

6. Mounted detachments will form their camp in front of picket line under direction of senior detachment commander. Pack mule picket line will be parallel to detachment lines and just inside so that one stable guard will do for both. Unless specially directed to the contrary, no part of camp will be outside of detachment picket line.

7. Q. M. Sergeant Dearborn will be acting Commissary Sergeant, and will be in charge of the issue of fresh beef and rations. Company Q. M. sergeants will report to him for instructions at Winchester and other places where fresh beef or rations are to be drawn.

8. Guards will be established on four sides of camp as at Lowemont and two pickets on the road. The mounted detachments will furnish the guard for their side of camp—a running guard of four non-commissioned officers and eight privates. The dismounted companies will furnish running guards as directed daily.

9. The pickets will be established by one of the unmounted companies as follows: Two non-commissioned officers and four privates in each of two outposts, one ½ mile from camp in advance and one ½ mile in rear of camp, in the same manner as at Lowemont.

10. The mounted detachment in the advance guard will, as soon as camp is reached, establish a single mounted picket ½ mile in advance of camp and one ½ mile in rear of camp. These posts to be relieved every two hours from same detachment, until relieved at 6 P. M. by pickets. These pickets may dismount, but will keep on the alert. The detachment commander will see to the relief of these pickets at proper times.

11. Stable call will be sounded morning and evening. The mounted men will fall in for reveille with their nose bags and curry combs and horse brushes, and will be marched to the picket line immediately after roll call. Approximate time for evening stables, 4.15 P. M. Exact time will be given from day to day by the Battalion Commander.

Animals will be watered in the following order: 1st, the mounted detachments, in charge of the stable sergeant; 2nd, the draft and train animals, in charge of Mr. Stone; 3rd, the pack animals in charge of Corporal Foster. Men in charge will see that the animals are watered with as little confusion as possible, and returned to the picket line with as little delay as possible to make way for other detachments.

BY ORDER OF MAJOR LEACH:
H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant.

A police officer was detailed to inspect the camp before the assembly to see that company streets and adjacent grounds were properly policed. The commander of the rear guard was also charged with the duty of making a minute inspection of the entire camp site, giving special attention to any disturbances of ground, fences or other property which could possibly be made the basis of a claim for damages. He was instructed to see that all gates and bars were properly closed and that nothing was left in such situation as to give rise to reasonable complaint.

6. The order of march adopted remained unchanged until the last day. Upon leaving camp at Eureka Lake on September 19, 1902, the calls and order of march were arranged as indicated in the following memorandum with a view to entry into the maneuver camp. The service of security and information and the reconnoissance work were discontinued at the reservation line:

The following instructions are published for the information of the battalion.

Calls for To-Morrow.

Reveille, first call, 5.30 A. M.; reveille, 5.40 A. M.; assembly,	5.45 A. M.
Breakfast	6.15 A. M.
Police call	6.30 A. M.
General	6.45 A. M.
First call, 6.55 A. M.; assembly	7.00 A. M.

A and B Companies' mounted detachments will act as advance guard; A Company's detachment being the advance party, B Company's detachment being the reserve. The reserve will march 700 yards to 800 yards in front of the foot troops and will keep two or three connecting files to maintain touch with foot column. The support will be about 500 yards in front of the reserve, and the point 500 yards in front of the support. These bodies will keep in touch with each other and with the reserve by connecting files. Lieutenant Bower will command the advance guard.

The trains will start 20 minutes after the foot troops; followed at about 500 yards by the rear guard, consisting of D Company detachment commanded by Lieut. Knight.

Reconnoissance men may march anywhere between the point and the reserve.

When the point is in sight of camp it will halt and the column close up on it. When the column is closed, the following formation will be taken: 1st, battalion of unmounted companies in column of fours, officers and mounted file closers in the position prescribed in drill regulations; 2nd, the mounted company in column of twos 20 yards in rear of the battalion, commanded by the senior officer; 3rd, the wagon train, baggage wagons in front, 20 yards in rear of the mounted company; 4th, the pack train 20 yards in rear of the wagon train.

At this halt, special duty men will join their companies, and C Company will join the battalion; all men must carry their blanket rolls; colors will be unfurled.

BY ORDER OF MAJOR LEACH:
H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant.

7. The camp site assigned to the battalion was near the Division Headquarters on the crest of a ridge near the main road. It was restricted in area, but would have been an excellent site in any ordinary weather. As the weather proved to be extraordinary, presenting almost incessant rain, and as the sinks were necessarily dug on the slopes of the ridge and on lower ground than the camp proper, it was found impossible to keep them clear of water at all times. This was the cause of some adverse comment from the Division Surgeon and medical officers of the day. The reports of the latter were, however, so contradictory as to deprive them of most of their weight. On one day the report stated that the sinks were entirely too far from the company streets; the next day's report, by another officer, stated that the sinks were entirely too close to the company streets, and such alternations of opinions were frequent. Some medical officers of the day reported the sinks in good condition. Others, acting under substantially the same conditions, reported them in bad condition. A special report, adverse to the condition of the sinks, was finally made by the Chief Surgeon, and was referred to me for action. Upon this report I placed the following indorsement:

"Respectfully forwarded. The conditions of this camp are well set forth in the within report.

The men's sinks are now and have at all times been in perfectly sanitary condition. The officers' sink has at times been unpleasant to visit; though not more so than the average public closet in the best regulated cities.

So far as I am informed, there has been no case of sickness in this battalion traceable to sink infection. There is no possible connection of the sink drainage and the water supply, and there have been no flies or mosquitoes about the sinks at any of my inspections.

The Division orders with regard to sink police have been scrupulously carried out and all informal recommendations of medical inspectors have been carried into effect except one requiring earth to be thrown in to absorb the water, and another requiring each man to cover his own deposit with earth before leaving the sink. I had tried both these things before this camp was established and know them to be wholly impracticable. The deposits which can be individually covered are not dangerous, and those which are dangerous can not be so covered.

I would much prefer quick to slacked lime for use in the sinks, but as the battalion has used open sinks continously since last April and has never been able to obtain a pound of quicklime, I conclude that there is some difficulty connected with its supply.

I deprecate the freer use of earth in the sinks as it is not necessary and will devolve upon men already worked to their full capacity the labor of frequently digging new ones.

I recommend that no change be ordered in the policing of the sinks of this camp.

SMITH S. LEACH,
Major, Corps of Engineers,
589-1902 Commanding 1st Battalion of Engineers."

No further communication reached me on the subject and no modification of the standing orders was made.

8. The camp routine was regulated by Battalion General Orders No. 78 as follows:

1. In compliance with General Order No. 3. Headquarters, Maneuver Division, Camp Root, Fort Riley Reservation, c. s., the following calls will be observed by this battalion until further orders:

Reveille, first call, 5.45 A. M.; reveille, 5.55 A. M.; assembly,	6.00 A. M.
Police	6.00 A. M.
Mess	6.20 A. M.
Stables, 6.50 A. M.; assembly	7.00 A. M.
Sick	7.05 A. M.
Water	7.45 A. M.
Drill call, 8.20 A. M.; assembly	8.30 A. M.
Mess	12.00 M.
Drill call, 1 P. M.; assembly	1.10 P. M.
Water and stable calls, 3.35 P. M.; assembly	3.40 P. M.
First sergeant's call	4.50 P. M.
Police, 4.55 P. M.; assembly	5.00 P. M.
Guard mounting, first call, 5.10. P. M.; assembly	5.20 P. M.
Parades when specially ordered.	
First call, 5.15 P. M.; assembly	5.30 P. M.
Retreat, first call, 5.45 P. M.; assembly	5.55 P. M.
Mess	6.15 P. M.
Tattoo	9.00 P. M.
Call to quarters	9.45 P. M.
Taps	10.00 P. M.

All calls will be sounded first by the trumpeter of the guard at Division Headquarters, and upon completion of the last note, will be repeated in the various camps concerned.

When parades are held, guard mounting will immediately follow.

Formations at reveille and retreat will be under arms.

Companies will be inspected at retreat. A commissioned officer will be present in each company at roll calls.

Drills will be held when specially ordered by the Battalion Commander.

BY ORDER OF MAJOR LEACH:
H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant.

9. Careful attention was given to the matter of reconnoissance of the route of march, not only with a view to producing a proper map of the road traversed as required by Department General Order, but with the further object of ascertaining, if possible, how much work could be done without delaying the march of the column. This work was under the immediate direction of Lieutenant N. E. Bower, who was detailed as Topographical Officer. It is only just to say that the excellent results obtained were, in a considerable degree, due to the energy and efficiency of that officer. With a few exceptions, the reconnoissance work was done by mounted men. They were invariably sent out in pairs, consisting of an observer with the Cavalry Sketching Case and a timer whose business was to keep the time and give constant attention to the gait. The pairs had been timed for rate and a proper scale was used for each. It was found necessary to re-time on the march as the gaits of the animals changed slightly under the work of the march. Two odometers were used on the bridge train, and their readings were taken at the beginning and close of the march, the distance so determined being used as a check on the distances brought in by the main road parties. It was at first attempted to use the odometer readings as a means of adjustment, but the discrepancies between the readings of the two instruments, which should have been identical, and other irregularities soon indicated that quite as much reliance could be placed upon the sketching boards as on the odometers.

In round numbers 350 miles of road and the adjacent country on each side were sketched and mapped. The general arrangement of the party, as stated by Lieutenant Bower, was to put the best man on the main road and to detail one man to assign the other pairs to side roads. In addition patrols were sent out on long routes to bring in maps of adjacent and sometimes parallel roads. The second best men were usually placed on these patrols. All such sketches were properly marked so that they could be quickly placed when brought in.

As soon as camp was pitched the drawings were assembled in a tent set aside for this purpose and the map compiled. The compilation was done by taking the sketches off the boards, trimming them to proper size and shape and pasting them in their proper relative positions to a piece of drawing paper. The map could be put in fairly good form in two hours after the command arrived in camp, but frequently extra work was put on it in the way of extended areas of topographical signs, and the enlisted men who desired to do so were permitted to work until taps. It is to be noted that of over 300 miles of road actually mapped, all but three miles was done by enlisted men of this battalion. In compiling the map from the sketches, the Topographical Officer gave his personal assistance, as well as supervision, and was voluntarily assisted by several officers and enlisted men.

The map as thus compiled at the close of the day's work was a pasted mosaic in pencil ready for reproduction. The latter could not be done on the march as no method had been worked out or facilities provided for doing it. The sheets were reproduced by tracing and blue printing during the stay of the battalion at Fort Riley and copies were submitted to the Division Commander. I invite attention to Appendix 1 to this report, embodying report of the Topographical Officer with his letter transmitting the same, and the indorsement of the Division Commander thereon. This map and Lieut. Bower's work in connection therewith were subjects of favorable mention in the report of the Division Commander to the War Department.

After the return of the battalion to Fort Leavenworth, the map was reproduced on reduced scale for more convenient use as a road map. There are enclosed with this report one set of blue prints,* in 11 sheets, of the route sketch made from Fort Leavenworth to Fort Riley and return; one set of blue prints, 3 sheets, of same sketch but on reduced scale; and blue print of reconnoissance sketches of Fort Riley reservation; one working sheet† showing method of joining together the pieces of work turned in by the different sketchers. The names of the enlisted men working on these sketches are given on plate 11. All the sketches were made with the Cavalry Sketching Case.

10. The report of the march to Fort Riley submitted to the Adjutant General of the Maneuver Division on arrival forms Appendix 2 of this report.

11. September 19th and 20th were occupied in making camp, ditching, digging sinks, etc. Sunday, the 21st, was also devoted in part to the same work. On Monday, September 22d, one company was engaged in constructing a road and bridge across the gorge of One Mile Creek, leading from the main road in a northeasterly direction to the Field Hospital, and materially shortening the distance from Headquarters to the Field Hospital and to some of the infantry camps. This work was continued on the 23d. A second company was assigned to the duty of making a hydrographic survey of the Kansas River through the limits of the reservation. A corporal and two privates were assigned to special duty as assistants to Major Macomb, Artillery Corps, Hydrographic Officer of the Maneuver Division. The survey of the river was continued as opportunity offered during the entire encampment, but on account of the rise of the river, run of drift, and pressure of other duties, and the lack

* Not printed. † Printed.

for most of the time of any boats which could be used, prevented any substantial progress although valuable instruction was obtained.

Company C was assigned to the unloading of ponton material shipped by rail, the assembling of the material at the river, and the construction of the bridge.

The fourth company constructed a bridge over Three Mile Creek on the main road to avoid fording by the foot troops. One Birago trestle and balks and chess for two bays were used. Approaches were cut to the bridge and the approaches to the ford for the use of wagons were also improved.

Company D also prepared near the camp specimens of trenches of various kinds, entanglements, etc., which were used to illustrate a lecture on the subject given by Captain Cavanaugh to more than 100 National Guard officers.

As men could be spared from time to time mounted reconnoissance parties were sent out on the various roads and trails of the reservation. This work was undertaken mainly for the purpose of instruction and demonstration, but it was immediately discovered that the existing maps of the reservation were not at all accurate, and this work was thereafter prosecuted with a view to obtaining material for their correction.

12. The various lines of work above noted occupied the companies assigned to them at all times when they were not participating in some of the maneuver problems. The battalion was called upon to take part in a majority of these problems. The entire battalion participated in the exercise of September 24th, forming a part of the blue forces under command of Colonel C. W. Miner, 6th Infantry. The problem consisted in the formation of an outpost for an army corps, with exercises in attack and defense of same, and the blue force had the defensive rôle. The foot sections under my own command, with the Battalion Surgeon and Field Hospital, were assigned to a position in the right center of the line, holding a bold hill lying between the two branches of Forsythe Cañon. Two mounted sections and the pack train were assigned to the extreme right as supports to the mountain battery and to assist it in intrenching. My report to the Adjutant General of the Blue Army, dated September 24, 1902, is given in Appendix 3. The report of the operations of the mounted sections was not made through me, but I have unofficial information that they rendered efficient service and that the equipment appeared to be in the main satisfactory. Only intrenching tools were taken in the canvas pouches made to ride on the aparejo. The mobility of the pack train and the ease and rapidity with which tools

could be gotten from the pouches and replaced seem to be all that could be desired.

13. In the problem of September 26th, which was the exercise of each infantry regiment as advance guard of an imaginary division involving the employment of artillery, one-half of Company A was assigned to the 6th Infantry; the other half to the 18th Infantry; the mounted section of Company B to the 22d Infantry. Company C and the foot sections of B and D worked on the bridge. No reports were made to me of the operations of the parts of the commands which participated in the exercise. Attention is invited, however, to the reports of Company Commanders on the general operations during the maneuvers which contain some information with regard to the movements of these parts. (See Appendix 7).

14. In the problem of September 27th, "the entire force on the march with suitable advance guard for a division of full war strength; advance guard entire; main body in part imaginary," the entire battalion participated as a part of the blue forces. The mounted section of Company B was assigned to the support of the van guard. The rest of the battalion and the light bridge train, tool wagons, and Battalion Hospital were assigned to the reserve. No orders were received further than those assigning the battalion to its position in the column. The line of march was followed part way through Governor Harvey Cañon, diverging near the head over a rough trail to the right. Shortly after leaving the main road the trail led up a steep ascent of about 50 yards over the rim rock, very rough and difficult. Some hospital wagons ahead of the battalion could not make the ascent and teams and men were sent forward to assist them. One company was detailed to improve the road, which was done by filling depressions with loose rock lying near and a little shoveling. The company was left to assist the bridge train over the difficult piece of road and the battalion moved forward. The trail led along the foot of a rather steep slope. No grading had been done and the trail consisted only of two wheel tracks in the grass. At one point the cross slope was so steep that the tool wagon upset. It was quickly righted, tools reloaded, and the march resumed, but enough time was lost to open quite a gap in the column.

No orders having been received, the battalion was assembled in a draw in rear of the deployed line and under cover, and messengers were sent forward to endeavor to find the Brigade Commander and ask for instructions. A few minutes later the Brigade Commander rode up to the battalion, asked how many mounted men there were, and on being informed ordered them put in the line on the right of the 18th Infantry. The mounted sections were moved forward, dismounted under cover and deployed on the line. After inspection of the deployed line by the Division Commander, recall was sounded, the mounted detachments rejoined, and the battalion was marched back to camp. In passing Headquarters the column was reviewed by the Brigade Commander.

15. In the problem of September 29th, "contact of opposing forces of all arms," the entire battalion participated. Company C, under command of Lieutenant Burgess, was assigned to the support of the advance guard. The remainder of the battalion, with company wagons and hospital, formed the reserve of the advance guard. This problem was without special incident, as the part of the line in which the battalion found itself was at no time engaged. My report to the commander of the advance guard forms Appendix 4, and the report of Lieutenant Burgess upon the operations of the detached company form Appendix 5.

16. In the problem of October 6th, "attack and defense of a position," the entire battalion less one company (C) was engaged, the blue forces, defensive, in that problem being under my command. This exercise is minutely described in the report of the Chief Umpire, and nothing further seems to be necessary here, other than to refer to my report of the action to the Adjutant General of the Maneuver Division, which forms Appendix 6. Further details may be found in the reports of Company Commanders which form Appendix 7.

17. In the exercise of October 7th, "tactical exercise of a division," the battalion formed part of the blue force on the defensive. I was excused from participation on that day, and the battalion was under the command of Captain Zinn. The foot sections were put on the line at the extreme left of the blue force. The three mounted sections were united in a provisional company of two platoons, Lieutenant Pope commanding, and Lieutenants Knight and Bower commanding platoons. A detachment of about 12 men of the 8th Cavalry was attached to this company. The company formed part of the advance guard, and after the engagement opened, was broken up into patrols. An umpire informed me unofficially that one of the best pieces of patrol work he had seen during the maneuvers was performed on this day by a small mounted squad under the command of an engineer officer. It was evidently one of the patrols from this mounted company, but the name of the officer was not given.

18. On October 8th, part of Company B began the construction of a double lock spar bridge over a gully just east of Three Mile Creek. The rest of this company and Companies A, C and D dismantled the bridge, assembled the material, loaded the wagons, hauled them to the depot and

entrained. All of the material was loaded during the day except seven wagons. These were loaded early the next morning.

19. Orders were received from the Division Commander to turn eight escort wagons with teams and drivers over to the 6th Infantry for the return march, transportation to be re-transferred on arrival at Fort Leavenworth. The foot sections of the battalion were ordered to return by rail; the mounted sections and train, by marching. The Battalion Commander and Staff accompanied the road column. Camp was broken on the morning of the 10th, baggage loaded and foot sections entrained by 11.00 A. M., at which hour the mounted sections and train took the road for Fort Leavenworth. About a half mile from camp, the column was passed by the train containing the rest of the battalion.

On the return march, no security and information work was done. The train moved out of camp usually a few minutes after daylight, the rest following about 7:30 A. M., or from an hour to an hour and a quarter behind the train. Some reconnoissance work was done to fill in gaps left on the way over and to explore some alternative routes. Between Manhattan and Wamego, a road on the south side of the river was taken with a view to avoiding a heavy stretch of sand which was encountered on the outward trip. Very little was gained, however, as the southern road was heavy with mud. In a very dry season the southern road would be best, but at all other times the northern road is preferable. The road column reached Fort Leavenworth at 1.00 P. M. on the 17th, with men and animals in good condition.

EQUIPMENT.

20. The bridge train taken on the road consisted of one division of the light equipage, less the forge wagon which was sent by rail as there were not sufficient animals to draw it. Each wagon was drawn by four mules, driven with a jerk line. The material was of standard pattern, loaded as prescribed, except that the rigid splinter bars had been replaced by double and single trees and that lever brakes had been attached to all wagons except the tool wagon, these changes having been made under the authority of the Chief of Engineers. The brakes were intended to be operated by the teamster from his saddle on the near wheeler by a line attached to a brake lever of ordinary form. This arrangement, though practicable, gradually fell into disuse, since as no ambulance was provided, the men unfit for marching were compelled to ride on the wagons of the train and for obvious reasons were distributed as widely as possible, and it was soon found that the men riding on the wagons had relieved the teamster of the

duty of working the brake. The change in the draught rigging gave entire satisfaction, and I feel justified in recommending as the result of this experience that all the rigid splinter bars be replaced, as soon as possible, by double and single trees. Persons competent to express an opinion on the subject are of the opinion that the mules would have suffered severely on this march if they had been compelled to pull on rigid fastenings. As it was, there was not a sore shoulder or a collar mark, so far as my knowledge extends, when the train pulled into Fort Riley. The road test was not severe. Part of the route was hilly, but the roads, as a rule, were hard and smooth. Some difficulty was encountered from chess working out of place, the arrangement for holding them not appearing to be sufficiently positive.

As before stated, Company C was assigned to the bridge train for the maneuver period, and made the march over alongside the wagons. Captain Flagler, in command of this company, was constantly present with the train, and has submitted a very complete report, to which especial attention is invited. It forms part of Appendix 7.

In the exercise of September 27th, (paragraph 14 of this report), in dragging the train over the rim rock, as described, every one of the old pattern chess wagons, having a sort of crib work over the front bolster, was broken. The new model chess wagons, having a solid bolster and a steel plate for fifth wheel, proved entirely satisfactory.

21. On the return march the same train was hauled with the substitution of sound wagons for some of the broken ones, but a different loading of the ponton wagons, suggested by Mr. Stone, the Master of Transportation, was tried. A floor was made of the seven balk, the two side frames were placed on edge bottom up against the bolsters on either side, the ponton cover in its box, chess and small articles placed between. This load carried well and for this occasion had the advantage of forming a very convenient receptacle in the rear for such articles of baggage as it was necessary to put on the train, in view of the fact that our wagon transportation had been turned over to the 6th Infantry, and that the pack train was loaded mostly with tools. Some difference of opinion exists among the officers of the battalion as to whether this method of loading is superior to the old. I am not at present prepared to make a recommendation.

22. The construction of a bridge was begun immediately on arrival, and the constant rise of the river and heavy run of drift prolonged the work through the entire period of the maneuvers and gave the officers and men of the battalion a most valuable experience.

The rise in the river increased its width so much that, in order to span it, it was necessary to use all the wooden pontons and seven trestles. The men had had but little boat drill and exclusively in still water. I felt a good deal of concern as to what the results would be in attempting to handle boats in the swift current. I was surprised and gratified to find that little or no difficulty was experienced, the boats being handled with celerity and precision.

As the material used was of uncertain age and some of it apparently weakened by decay, I directed that seven balk should be used in each bay instead of five, and that all put in the bridge should be individually tested. The details of this work are described by Captain Flagler in the report cited. But few rejections were made, and if I could have known the result of the test in time, I would have had the bridge built with five balks instead of seven as it would have been amply strong.

23. The most important point developed was the adaptability of the Birago trestle for use in swift currents of considerable depths over a movable bottom. The trestles were strengthened when set, by a line from an anchor upstream leading to the upstream end of the cap and hauled taut. The object of this was mainly to cushion the impact of drift and it was very successful in that respect. It also relieved the trestle from severe cross strains due to the pressure of the current and drift and made possible the adjustment of height of cap. The rise of the river and the settlement of the shoes of several of the trestles brought the upper side of the roadway at one point under water. The urgency of the case made it necessary to try at least to raise the caps, and the trial was so successful as to lead me to believe that under any ordinary circumstances no difficulty will attend this operation. I am now of the opinion that no great sacrifice of weight or simplicity of the trestle should be made in order to introduce a facility of cap adjustment.

24. The pack train equipment consisted of aparejos and their accessories. As there were only three mounted sections, the "C" mounted section having not then been fully organized, the train was divided into three parts, each of identical organization, and one was assigned to each section to be taken out whenever necessary by the section, but concentrated on the march. Six canvas pouches, designed by the chief packer, were made before starting, arranged to go on the aparejo and to be fastened to it by straps which did not interfere with the opening of the flaps of the four pockets which each pouch contained. The lower pocket was long enough to take shovels and pick handles. The upper pouch was long enough to take picks, bill hooks and other similar tools. The pouches

were of sufficient size to carry, when fully loaded with the average assortment of road and bridge tools, all that one mule could carry. These pouches gave great satisfaction, the only criticisms to be urged against them being that the material of which they were made was not suitable, and it was known not to be when it was used, and that the design was defective in some trivial details. The other packs were made up in the conventional way, the cargoes being arranged in side and top packs and put on with lair ropes and diamond hitch.

Not only did the pouches require less time to load in the morning and unload at night, but no case is known of a pouch requiring attention from the packers on the march, while on the other hand, the pack train could scarcely be approached at any time without some of the packers being found dismounted readjusting some of their packs. About half an hour or three-quarters after starting in the morning a majority of the packs required readjustment, and the march of the train was delayed several minutes to permit this. Considered merely from the standpoint of a loading device, the pouch is much superior to the diamond hitch and should be preferred whenever it can be used. There was frequent occasion to open a pocket, take out some tool, use it for a few minutes, and replace it, in which operation no other part of the load was disturbed and no time was lost in re-packing.

Based on this experience, an attempt is now being made to extend the same principle to boxes of standard size, so arranged on the aparejo that they can be unlocked and opened without disturbing the fastenings to the saddle.

25. The wagon transportation consisted of the escort wagons supplied by the Quartermaster Department of which there were two for each company, the scheme being that one should be used for rations and baggage and the other for tools and engineering supplies. The result was that in most cases the two wagons were used indiscriminately for the two purposes and the loads were very much mixed. This was more or less of a necessity since both wagons had to be loaded to the tops of the bows in order to carry the material which had to be transported, and it seemed almost necessary to make the top loads of both wagons out of the lighter and more bulky materials and the bottom loads of the heavier stuff, and in its practical importance this classification seemed to outweigh the original one of baggage and tools.

The question of the suitability of the escort wagon for transportation of baggage and rations does not fall within the scope of this report. As to its adaptability for carrying engineer tools, the result of this experience is, on the whole, unfavorable. The rigid sides of the wagon are not high enough to retain the loads properly. It is difficult to pack tools, especially edged tools, so that they will not be injured in transportation by rubbing together. It is not practicable to arrange loads so that the tools wanted at any particular time can be gotten out without disturbing the rest of the load, and finally, but by no means least in importance, engineering tools and supplies in the ordinary escort wagon are not secure from the weather and from trespass. A special tool wagon seems to be required and two designs are now under experimentation by two companies of the battalion and a third is proposed and will soon be constructed for trial.

The Headquarter's baggage, mess outfit, tentage, and photographic, draughting, and map-making outfits were transported upon a large six-mule stake wagon which was constructed by enlisted men of the battalion from the Quartermaster's scrap heap. This wagon was the most serviceable one we had as regards convenience of loading and unloading and freedom from shifting of load during the march. Time did not permit any systematic packing of the photographic, draughting, and map-making outfits. They were mainly taken in the boxes in which they were received from supply houses and other sources. The obvious inadequacy of this arrangement makes it unnecessary to comment further upon it. The photographic and map work was in the immediate charge of the Adjutant of the battalion, whose report thereon, containing some suggestions as to arrangement and packing, will be found in Appendix 8.

26. In the following recommendations of Company Commanders on the subject of equipment, I concur and recommend that steps be taken to make them effective.

By CAPTAIN FLAGLER:

That all wagons be equipped with single and double trees and brakes.

That one of the boathooks prescribed for each ponton be made sharp on hook and point, similar to log hooks, for convenience in handling the drift.

That each company be provided with 12 oil skin coats and hats and 24 pairs of fishermen's rubber boots.

That a suitable block and fall with slings be provided for raising and lowering trestle caps without dismantling bridge.

That the top of a trestle leg be modified in form to stand continued blows of maul without brooming and splintering. When the trestles are wet, it is found that considerable driving on legs is required.

That four false legs be supplied with each trestle.

By CAPTAIN FLAGLER and LIEUTENANT STICKLE:

That each division of the bridge equipage be supplied with a small boat for general work, such as soundings, life saving, etc. A suitable boat for this purpose is described in some detail by Captain Flagler.

By CAPTAIN CAVANAUGH:

The addition to the organization of the battalion of a veterinary with the rank and pay of sergeant, to perform also the duties of stable sergeant; a farrier and horseshoer for each section, to have the rank and pay of corporal, and the enlistment of special men as teamsters for the bridge train, with such compensation as will make their emolument equal to that of civil employes doing the same work.

26. The site of the bridge, cross sections of the river, elevation of the trestle end, and sketches of the cap-hoisting device, and proposed modifications to trestle leg, accompany the report of Captain Flagler.

Very respectfully,

SMITH S. LEACH,
Major, 1st Battalion of Engineers.

APPENDIX NO. 1.

CAMP ROOT, FORT RILEY, KANSAS,
SEPTEMBER 22, 1902.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS.

SIR: I have the honor to submit herewith my report and itinerary as topographical officer for the march from Fort Leavenworth to Fort Riley, Kansas.

I forward also the maps compiled from sketches made by the enlisted men of the battalion, in eleven sheets.

Very respectfully,

N. E. BOWER,
2d Lieutenant, Corps of Engineers,
Topographical Officer.

GENERAL REPORT OF THE MARCH FROM FORT LEAVENWORTH TO FORT RILEY, KANSAS, SEPTEMBER 8 TO SEPTEMBER 19, 1902.

Being a summary of the daily reports.

The roadway. The road is the ordinary country road. It is fenced off into three widths, 30 feet, 40 feet, and 60 feet. As a rule but one track of about 9 feet width has been used.

The remainder of the roadway where the road machine has not been used recently is grown up with weeds, sunflowers, or sometimes underbrush. Teams can pass anywhere excepting on bridges, but it would scarcely be advisable to move two abreast even on the best portions excepting in emergencies. In some places recent repairs have been made, but for the most part few repairs have been made in the past year. The numerous hills materially aid drainage, and these with the existing side ditches keep the road in fair condition. The road is hilly from one end to the other. Only two marches may be said to have been made on level road, viz, from Reform Farm to Silver Lake and from Silver Lake to St. Marys, a total distance of 26.42 miles. The roadway, previous to reaching Reform Farm, is, however, much more hilly than afterwards. The worst portion of road is two miles on either side of St. George. This portion combines hills with deep sand, making marching difficult, but the advance guard bridge train was taken through with two mule teams per wagon without difficulty. The nature of the soil is such that deep washouts or gullies at right angles to the road are numerous, causing much bridging. Low portions of the road would give difficulty in very wet weather.

Bridges. All large bridges, with two exceptions, are of steel or iron. The small bridges are of wood. As a rule they are in good repair and sufficiently strong for all ordinary loads. Their height is, with few exceptions, in the small bridges, above the high water mark. A few large bridges have pile piers or abutments, the rest have stone.

Cities. These vary in size from 50 (Lowemont) to 3,500 (Manhattan). Topeka has 40,000 population, but was not passed through. Frame buildings are used throughout up to Reform Farm. Beyond this a good building stone is easily gotten and consequently many stone buildings are found in the towns and villages. Manhattan is a marked example of a city built in the neighborhood of good building stone. Every place has at least one railroad passing through. Telegraphic and telephonic communication is easily gotten to all points, and rural delivery prevails throughout.

Streams. Streams are found in sufficient number to insure water for a command however large passing through. After passing Reform Farm the Kansas River is nowhere more than two or three miles distant and in many places close to the road. The banks of all streams and of the Kansas River in places, is uncleared land and hence they can be located a long way off.

Country. The country may be said to be hilly throughout, including the reservations at the termini of the route. The lay of the land greatly favors the defensive. The roadway usually visible from not far distant hills. The land is practically all farm land and hedge and wire fences are everywhere used. Corn is very extensively planted. The appearance of the crop indicates a very productive soil. Large orchards here and there show a heavy yield of apples this year. Hay can be easily gotten along the route. From one point about 3 miles north of Meriden 28 hay stacks were counted. Views of 15 or 20 miles are occasionally gotten from an eminence, but usually 3 or 4 miles is the limit.

Camping grounds. Camping grounds were hired in advance for the command and fuel, hay and grain were purchased from nearby farmers and delivered at the camp grounds usually before it was reached. The places chosen were some excellent, some quite poor. A total distance of 4.7 miles was lost in going into camps selected off the main road. Camp grounds were hired at all places excepting at Kilmer where a railroad siding was occupied. Water was always found in abundance and was generally good.

Railroads. Railroads were found in all the towns passed through giving connection with Leavenworth or Kansas City. The maps give these roads wherever they were found.

Telegraph lines. Telegraph lines in general are along all the roads passed over.

DIARY.

The command comprised the 1st Battalion of Engineers, with the advance guard bridge train and the pack train. A detachment of the Hospital Corps accompanied. Leaving Fort Leavenworth at 9.55 A. M., September 8, 1902, Fort Riley was reached at 10.45 A. M., September 19, 1902. The total distance marched was 143.86 miles. Number of days marching, 12; average distance per day, 11.99 miles. The shortest march was 7.12 miles and the longest 15.94 miles. On the longer marches a stop of about 1¼ hours for lunch was taken. The total distance lost in going into camps was 4.7 miles. The total distance lost in taking wrong roads was 3.25 miles. The total distance therefore might have been reduced to 135.91 miles.

The command would start in the morning at hours designated by the Commanding Officer the preceding evening. The time varied between 6.30 A. M. and 7.30 A. M. The order of march was as follows:

The advance guard (one mounted detachment after the reconnoissance men had been taken away); three dismounted companies; one mounted detachment as train guard; the wagon train, followed by the bridge train; the pack train; the rear guard (one mounted detachment). The wagon and bridge train started twenty minutes after the dismounted men, and the pack train twenty minutes later. Halts were made by the dismounted men after every fifteen minutes of marching and the teams would catch up with them at the end of the second or third halt.

The weather previous to and on the march was dry. Two light showers on the march had no effect on the roads.

NOTE.—Errors have doubtless crept into this report and into the map work, but every possible care has been taken to make both as nearly correct as possible.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

EXPLANATION SHEET.

(To accompany report.)

Grades.

Grades in maps are expressed in degrees. The top and bottom of each hill is marked by a line at right angles to the road, and an arrow between these lines shows the direction of water flow.

Numbers.

Numbers inclosed in circles correspond to numbers in written report of bridges.

Numbers inclosed in squares correspond to numbers on the same sheet and show who made the drawing on which they were placed.

Letters.

Letters on drawings correspond to letters in written report.

Main road.

The main road is distinguished by having no numbers in squares on any of its pieces.

Distances.

Distances were taken by odometers and the reconnoissance parties got their distances by the time method.

To obtain distances by the former odometers were put on both front wheels, and the average number of revolutions and the average circumference of the wheels used to compute the distance.

In the latter case the best results were gotten by timing the horses in pairs, and having a paper scale made and pasted on the rule of the sketching case.

Sketching case.

The Cavalry Sketching Case was used exclusively.

Method of getting and using sketches.

The reconnoissance party, consisting usually of four or five pairs, started out just before the column. The best man was given the main road and usually one man detailed to assign the other pairs to side roads. Proper marking was put on all side sketches so that they could be quickly placed when brought in. In addition, patrols were sent out on long routes to bring in maps of adjacent and sometimes parallel roads. This brought in much valuable information, as the maps attest. The second best men were usually placed on these patrols.

Compiling.

As soon as camp was pitched the drawings were assembled in a tent set aside for this purpose and the map compiled. The map could be put in fairly good form in two hours after the command arrived at the spot, but frequently extra work was put on them and the enlisted men were permitted to work till late in the evening. All the outside work excepting about 3 miles of over 300 miles of road was done by enlisted men. They were used frequently in helping compile the maps and put finishing work on them, which they did cheerfully.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer

REPORT No. 1.

Fort Leavenworth to Lowemont, Kansas, September 8, 1902.

I. The roadway.

The road is the ordinary dirt road, fairly well drained by throwing or scraping dirt from the gutter to the center. No repairs, however, seem to have been made recently. For about 3 miles the width is 30 feet, after that 60 feet. Stone for repairs is not near at hand but forest timber sufficient to corduroy wet places can be gotten conveniently. All grades are given in accompanying map. About [illegible] miles from Fort Leavenworth there are two railroad cuts near the road and close to each other, depth about 30 feet and adjacent hills thickly wooded, timber generally small. Fences are all [illegible] about one mile of hedge.

II. Bridges.

One queen post truss [illegible] span [illegible] feet above water, stone abutments, single track, [illegible] and of ordinary strength, in good repair.

III. Rate of march.

Time [illegible] distance [illegible] miles.

Villages.

Lowemont. Lowemont is a [illegible] village of [illegible] people. [illegible] 2 [illegible] telegraph office and [illegible] and a small store.

Streams.

The only stream [illegible] Creek. This is small and [illegible] feet deep [illegible]

Country.

The country [illegible] favors the [illegible] would afford [illegible] and good. [illegible] ploughed fields [illegible] for short distances only. A view of many miles gotten when near and at Lowemont.

Camping grounds. Very good at Lowemont. No good places for large command intermediate on account of scarcity of water. A grove about 3 miles from Fort Leavenworth large enough for two regiments to camp. Water would have to be gotten at farmhouses. Water at Lowemont was gotten from ponds and railroad station-house.

Railroads. See maps.

Telegraph lines. After passing railroad cut, 15 wires to Lowemont; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 2.

Lowemont to Easton, Kansas, September 9, 1902.

The roadway. Country road, varying between 20 and 60 feet in width as fenced off, but scarcely ever more than 9 feet can be called road. The rest would require much work to make it passable. All grades given in accompanying drawing. Attention is invited to several hard grades in this march. Timber for repairs easily gotten. Hills give good drainage of one kind. Road scraper was used recently on part of this road. One-half mile east of Easton is a defile one-third mile long. High and heavily wooded flanks and bad road through it.

Bridges. The following bridges were found on the march:

1st. Wood; 8-foot span, 6 feet high; stone abutments; 2 x 10 inch balk and logs; 1½ inch and 2 inch plank; cross gully; condition good.

2d. Wood; 10-foot span, 6 feet high; stone abutments; 2 x 10 inch balk and logs; 2 inch plank; condition good.

3d. Four plank wide; 4 feet high; condition good.

4th. Wood; 8-foot span; 3 feet high; stone abutments; same material as second; condition poor.

(2) NOTE.—This bridge broke down under the advance guard bridge train.

5th. Wood; three plank; 2 feet high.

6th. Wood; 110 feet (paced); 25 feet above water; width, 15 feet; approaches of 30 foot and 20 foot spans; (3) simple Warren truss; good stone piers; roofed.

7th. Wood; trestle bridge, two trestles, rotting; one (4) post reinforced with plank; length, 40 feet; height, 25 feet; width, 15 feet; pile abutments; strength doubtful for siege guns. This bridge could easily be repaired or reinforced by timbers from adjacent woods.

Rate of march. Time, 7.40 A. M., 10.30 A. M.; distance, 7.12 miles: teams must march single; two abreast only after much road work.

Villages. Easton; population, 400; principal buildings, Leavenworth, Kansas and Southwestern Railroad station, post-office; telegraph and telephone to all points; three grocery stores, two hardware stores, two blacksmiths and wagon makers. This place would be difficult of defense, as it lies in an amphitheater, surrounding hills being close.

Streams. Big Stranger Creek; width now, 15 feet; very muddy; slow current; steep banks, giving considerable depth when high.

Country. Greatly favors the defensive; soil very fertile; corn is the principal crop raised. A view of about 10 miles is gotten to either side of the road almost the entire distance. Large fields of kaffiir corn were passed. All arms could operate in this region.

Camping grounds. At Easton, water was gotten from a branch of the Big Stranger Creek. Farm house wells would have to be depended on at intermediate stopping places. Otherwise suitable ground in many places.

Railroads. Leavenworth, Kansas and Southwestern Railroad, given on map.

Telegraph lines. None on road.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 3.

Easton to Winchester, Kansas, September 10, 1902.

The roadway. Usual dirt road; the first two miles 30 feet wide, after that 40 feet wide; entire width passable and well drained, 8th. Wood; span, 10 feet; height, 4 feet.

9th. Wood; seven plank; height, 4 feet.

10th. A-shaped bridge; height, 4 feet.

11th. Wood; eight plank; height, 4 foot.

Rate of march. Time, 6.55 A. M., 2 P. M.; one and one-quarter hour's stop for lunch; distance, 15.94 miles.

Villages. Dunavant, small country village of 70 population; buildings, blacksmith shop and lumber yard; Kansas City and Northwestern Railroad depot, four passenger trains daily; telegraph and telephone to all points; frame buildings, difficult of defense.

Streams. None of any importance; small ones shown in map.

Country. Generally hilly; at A-A large table lands or plateaus of striking appearance; the river valley stretches out in prominent view traveling from B to B; soil good and productive; corn the principal crop raised; farm houses scattered at intervals of miles and fractions of miles.

Camp grounds. A large body of men could encamp in the vicinity of Osawkie as the Delaware River would furnish ample water for all purposes except drinking, and numerous wells would supply this.

Railroads. The Kansas City and Northwestern Railroad at Dunavant, and the Leavenworth, Topeka and Southwestern Railroad at Osawkie.

Telegraph lines. Three wires from Winchester to near Dunavant, where six more wires join from the south; poles poor, of 5 inches diameter and bark on.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 5.

Osawkie to Kilmer, Kansas, September 12, 1902.

The roadway. Ordinary country road, varying in width 30 to 40 feet; road reasonably well drained and hilly; fences, barb wire and a few miles of hedge; all grades given on map; between Meriden and Kilmer the wrong road was taken, and this road was very poor and hilly; the proper road was reported much better.

List of bridges. List of bridges:

1st. Bow-string truss, steel span, 125 feet; 30-foot (12) approach; stone piers and abutments; height, 20 feet above water.

2d. Six planks; height, 3 feet; condition good.

3d. Three plank; height, 2 feet; condition good.

4th. Six plank; height, 2 feet; condition good.

5th. Four plank; height, 2 feet; condition good.

6th. Stone culvert over gully; 8-foot arch; condition good.

7th. Four plank; height, 2 feet; condition good.

8th. Wood; span, 8 feet; height, 2 feet; condition good.

9th. Wood; span, 6 feet; height, 2 feet; condition good.

10th. Wood; span, 4 feet; height, 4 feet; condition good.

11th. Wood; span, 8 feet; height, 8 feet; condition good.

(13) 12th. Warren truss; steel span, 80 feet; height, 20 feet; stone abutments. A 200-foot railroad trestle just north of this bridge; condition good.

13th. Wood; span, 8 feet; height, 8 feet; condition good.

14th and 15th. Four-foot boxes; condition good.

16th. Wood; span, 15 feet; height, 6 feet; condition good.

(14) 17th. Wood and iron queen post truss; 60-foot span; height, 20 feet above water; pile piers; condition good.

(15) 18th. Culvert, 40 feet; height, 12 feet; condition good

Rate of march. Time, 6.40 A. M., 12.20 P. M.; distance, 15.39 miles.

Villages. Osawkie; population, 300; post-office, telegraph office, one blacksmith shop, three hardwares; Leavenworth, Topeka and Western Railroad depot.

Meriden; population, 300; post-office, Atchison, Topeka and Santa Fe Railroad station, and a branch of the Leavenworth, Topeka and Southwestern Railroad depot, one blacksmith, two hardware stores, bank, livery stable; telegraph and telephone to all points.

Streams. Delaware River, 30 feet wide to 50 feet wide, depending on the weather. Rock Creek, width, 30 feet; very muddy; stream crossed by bridge (No. 14 on map), 40 feet wide; stream crossed by culvert (15) 6 feet wide.

Country. Hilly and under good state of cultivation; view wide; village of Rock Creek and dome of State capitol visible from point B on map; pyramid-shaped hill overlooking Meriden at C; wire and hedge fences used extensively.

Camp grounds. Suitable camp grounds could be gotten along the streams mentioned above.

Railroads. See map.

Telegraph lines. Two wires to Meriden; place for six more; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 6.

Kilmer to Reform Farm, Kansas, September 13, 1902.

The roadway. Country road; fairly well drained and hilly, as shown on map; width, 30 to 60 feet; weeds and underbrush on either side of beaten path.

Bridges. List of bridges:

1st. Seven plank; height, 2 feet; condition poor.

2d. Two-foot box.

3d. Wood; span, 10 feet; height, 2 feet; condition good.

4th. Wood; span, 6 feet; height, 2 feet; condition good.

5th. Wood; span, 8 feet; height, 2 feet; condition good.

6th. Wood; span, 8 feet; height, 4 feet; condition good.

(16) 7th. Bowstring truss; steel span, 60 feet; height, 8 feet above water; pile abutments; 10-foot approach; condition good.

8th. Five plank; height, 2 feet; condition good.

9th. Wood; span, 10 feet; height, 3 feet; condition good.

10th. Wood; span, 6 feet; height, 8 feet; condition good.

(17) 11th. Steel truss; span, 65 feet; height, 30 feet; approaches of 40 feet and 25 feet; very good stone piers.

Rate of march Time, 7 A. M., 10 A. M.; distance, 9.2 miles.

Villages. Kilmer; nothing more than a railroad siding; Atchison, Topeka and Santa Fe Railroad passes here (through trains.)

Streams. Indian Creek; 15 to 20 feet wide; clear water.

Soldier Creek; 30 feet wide, 4 to 5 feet deep; banks steep, muddy.

Country. Rolling farm lands; fields divided by hedge and barb wire fences; dome of capitol visible at A and B and frequently thereafter.

Camp grounds. Camp grounds could be gotten along either of the streams mentioned above.

Railroads. None along route.

Telegraph lines. Two wires; place for eight more; part of the road had four wires; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 7.

Reform Farm to Silver Lake, Kansas, September 14, 1902.

The roadway. Road, 60 feet wide, practically level, low, and straight; difficult or impossible of drainage; wire and hedge fences; swampy places; considerable sand in road, thought to be bad in wet weather, but an inhabitant of Silver Lake stated that he had hauled two-ton loads to Topeka with three horses in all kinds of weather.

Bridges. No bridges.

Rate of march. Time, 7.30 A. M., 11.30 A. M.; distance, 11.68 miles.

Villages. Silver Lake; population, 250; blacksmith shop, post-office; telegraph and telephone lines to all points; about six stone buildings here; a main line of the Union Pacific Railroad passes through.

Streams. No streams, but Silver Lake is a considerable body of water.

Country. Generally level, soil sandy; view of two or three miles either side of road; dome of capitol and Washburne College in view to south of road.

Camp grounds. Would generally be chosen near the river which averages three-quarters of a mile from "the lower road." (See map.)

Railroads. A main line of the Union Pacific Railroad is near the road the entire distance.

Telegraph lines. Twelve wires with usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 8.

Silver Lake to St. Mary's, Kansas, September 15, 1902.

The roadway. Dirt road, 40 feet wide; fences, hedge and barbed wire; this road averages about 8 feet below the adjacent railroad track, and drainage is difficult or impossible.

Bridges. The following bridges:

1st and 2d. Wood; span, 10 feet; 8-foot stone abutments; condition good.

(18) 3d. Steel truss bridge; span, 70 feet; height, 25 feet; stone abutments; condition good.

4th. Wood box; 4 x 4 feet; condition good.

5th. Wood; span, 8 feet; height, 4 feet; condition good.

6th. Wood; span, 8 feet; height, 3 feet; condition good.

7th. Wood; span, 6 feet; height, 3 feet; condition good.

(19) 8th. Stone; span, 20 feet; height, 8 feet; condition good.

(20) 9th. Queen post truss; span, 14 feet; height, 8 feet; stone abutments.

Rate of march. Time, 6.30 A. M., 1.20 P. M.; distance, 14.74 miles; halt of one and one-third hours for lunch.

Villages and cities. Kingsville, about 30 population; stock yards and railroad station; 2.6 miles from Silver Lake on main road.

Rossville, population, 600; blacksmith shop, livery stable, stock yards, stores of all kinds, and bank; telegraph and telephone to all points.

St. Mary's, city of 1,500; site of St. Mary's College, boys' school, Catholic, registers 300 students in addition; principal street has many stone buildings on either side; site of camp overlooks the whole city; difficult of defense; Union Pacific Railroad depot.

Streams. 1. Cross Creek, at Rossvile, 25 feet wide, with steep banks, possibly very deep in wet weather.

2. Burbony Creek.

3. Creek under bridge No. (20), 8 to 10 feet wide, near St. Mary's.

Country. Rolling farm lands; for three miles before getting to St. Mary's hills to the north control the road; open country to the left.

Camp grounds. The site at St Mary's was well chosen on a hill overlooking the city; water was gotten from wells at the bottom of the hill.

Railroads. Union Pacific Railroad runs parallel to road. (See map.)

Telegraph lines. Twelve wires on road and twelve on railroad; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT No. 9.

St. Mary's to Waumega, Kansas, September 16, 1902.

The roadway. Dirt road, generally 30, 40, and 60 feet wide, and in fair condition; no unusual grades or very bad places; all grades given on map; last four miles of road a road scraper had been used recently.

Bridges. Bridges:

1st. Stone culvert; 8 feet long, 4 feet high; condition good.

(21) 2d. Steel truss; span, 30 feet; height, 10 feet; condition good.

3d. Wood; span, 6 feet; height, 4 feet; stone abutments; condition good.

4th. Seven plank; height, 4 feet; width of this bridge about 50 feet.

(22) 5th. Steel truss; span, 20 feet; height, 10 feet; approach, 10 feet; stone abutments; condition good.

(23) 6th, Steel truss; span, 20 feet; height, 20 feet; approach, 10 feet; stone abutments; condition good.

(24) 7th. Stone culvert 20 feet long, 8 feet high; stone abutments; condition good.

(25) 8th. Steel truss; span, 30 feet; height, 15 feet; stone abutments; condition good.

(26) 9th. Steel truss; span, 120 feet; height, 30 feet; approaches, 35 feet on either side; pile abutments; condition good; bridge in need of repairs; railroad bridge within 100 feet and strong; both have stone piers and abutments.

10th. Wood; span, 10 feet; height, 8 feet; near camp; condition good.

Rate of march. Time, 6.40 A. M., 1.35 P. M.; one and one-third hour halt for lunch; distance, 15.65 miles.

Villages. Belvue; population about 200; post-office, telegraph and telephone offices.

Waumega; population about 1,900; apparently flourishing little town on the Union Pacific Railroad; several stone stores and dwellings.

Streams. 1. Fitzgerald Creek, 8 feet wide; banks wooded and steep.

2. Riley Creek, clear water.

3. Terrain Creek.

4. Deep Creek, 20 feet wide now; banks very steep.

5. Lost Creek, small stream of clear water.

6. Vermilion River, about 65 feet wide; muddy and very steep banks; banks wooded.

Country. Rolling farm lands intersected with barb wire and hedge fences.

Camp grounds. Can be gotten near any of the above mentioned streams. That at Waumega excellent for small command, say, one or two regiments. City water can be gotten.

Railroads. The Union Pacific Railroad is in touch all along the route.

Telegraph lines. Some places ten wires; about four wires the entire distance; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 10.

Waumega to Elbow Creek, Kansas, September 17, 1902.

The roadway.

Road narrow, crooked, and hilly for about two miles after leaving Waumega; about one mile through woods, road good then till within about two miles from St. George. Here sand was struck and hills. In some places roadway was very narrow, due to washouts. Sand continued for about two miles beyond St. George. These four miles were by far the worst road of all for marching over or hauling heavy loads over in dry weather. At A the road is low and surrounding country swampy. Water covered the road for a distance of 75 feet to a depth of 12 inches. The dismounted men took the railroad track.

Bridges.

Bridges:

1st. Culvert 30 feet, 20 feet high; dry creek.

2d. Wood; span, 18 feet; height, 10 feet; condition fair.

(26) 3d. Wood; span, 10 feet; height, 4 feet.

(27) 4th. Wood; span, 20 feet; height, 8 feet; stone abutments; condition good.

5th. Wood; span, 8 feet; height, 4 feet; clear water; condition good.

The bridge across the Kansas River is a steel one of six bays resting on brick piers; condition good.

(28) 6th. Steel truss; span, 40 feet; height, 15 feet.

7th. Wood truss bridge; span, 20 feet; height, 4 feet.;
(29) stone abutments. Probably too weak for siege guns but can be flanked without great difficulty.

8th. Wood; span, 6 feet; height, 6 feet; stone abutments; condition good.

9th. Wood; span, 10 feet; height, 6 feet; condition good.

10th. Wood; span, 6 feet; height, 2 feet; condition good.

11th. Wood; span, 10 feet; height, 6 feet; condition good.

12th. Wood; span, 7 feet; height, 2 feet; condition good.

13th. Wood; span, 6 feet; height, 2 feet; condition good.

14th. Wood; span, 8 feet; height, 2 feet; condition good.

(30) 15th. Steel truss bridge: span, 40 feet; strong stone abutments; height, 30 feet; condition good.

16th. Wood; span, 10 feet; height, 10 feet; stone abutments; condition good.

17th. Wood; span, 6 feet; height, 2 feet; condition good.

Rate of March.

Time, 6.30. A. M., 1 P. M.; one and one-third hours halt for lunch; distance, 14 miles.

Villages.

St. George, population, 200; wagon works, Union Pacific Railroad station, stone buildings.

Streams.

1. Woody Creek.
2. Black Jack Creek, about 8 feet wide and 2 or 3 inches deep; water very clear.
3. Elbow Creek, width, 10 feet; 1 to 2 feet deep; banks very steep.

Country.

Hilly and woods only along streams. At C is a line of hills commanding the road for several miles. At B the road climbs along a side hill.

Camp grounds.

The camp ground at Elbow Creek was in a field and plenty of water was at hand. Here was ample room for a brigade encampment.

Railroads.

The Union Pacific Railroad is followed, crossed, and recrossed.

Telegraph lines.

None to St. George (error in map), after that four to Elbow Creek; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 11.

Elbow Creek to Eureka Lake, Kansas, September 18, 1902.

The roadway.

Country road of 30 and 40 feet widths. Generally in good condition in dry weather, but probably bad in wet weather. Defile and hilly road at A, after that swampy road, especially so at B, where water covered road to depth of 18 inches and dismounted men passed via the railroad.

Bridges. 1st. Bridge of three 120-foot spans, bow-string trusses,
(31) steel, and 100-foot trestle approach, wood; height, 35 feet above water; good stone piers and abutments.

(32) 2d. 200 feet south railroad bridge of two steel truss, spans of 150 feet each and 150-foot trestle approach; excellent stone piers and abutments; new piers 300 yards below for a bridge.

(33) 3d. Bridge, 75-foot span, steel truss; height, 25 feet; approach, 25 feet; good stone abutments; 200 feet south of railroad bridge of similar construction but stronger.

4th. Wood; span, 8 feet; height, 8 feet; condition good.

Rate of march. Time, 7.30 A. M., 11.15 A. M.; distance, 10.96 miles.

Cities. Manhattan, population, 3,500; many stone buildings. Nearly all stone on both sides of principal street; good building stone at C and perhaps nearer.

Eureka Lake, summer hotel.

Streams. 1. Big Blue River; width, 125 feet, probably twice as wide in wet weather.

2. Wild Cat Creek; width, 10 feet, and 1 or 2 feet deep. Gets probably 75 feet wide and 10 feet deep in wet weather.

3. Kansas River near at all times.

Country. Hilly and in many places covered with rocks in the neighborhood and west of Manhattan.

Camp grounds. Good camp grounds at D and at Eureka Lake for one or two regiments.

Railroads. Union Pacific Railroad close to road at all times.

Telegraph lines. Four wires to Manhattan; Manhattan, three or four to Eureka Lake, including an electric light wire; usual wood poles.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

REPORT NO. 12.

Eureka Lake to Fort Riley, Kansas, September 19, 1902.
Reconnoissance only to reservation limits.

The roadway. Country road in very good condition in dry weather, probably bad in wet weather; hills give fair drainage till the reservation is reached, after that the roadway is low and quite level.

Bridges. 1st. Wood; king post truss, span, 15 feet; height, 7 feet; stone abutments; fair condition. (34)

2d. Wood; span, 4 feet; height, 4 feet; condition poor.

3d and 4th. Two-foot boxes; condition poor.

(35) 5th. Same as first, excepting height, 10 feet; condition good.

(36) 6th. Wood; king post truss, height, 4 feet; floor poor; stone abutments.

7th. Wood; span, 12 feet; height, 8 feet; condition good.

Rate of march. Time, 7 A. M., 10.45 A. M.; distance, 9.98 miles.

Villages. Ogden, population about 200; blacksmith shop and wagon works, post-office, Union Pacific Railroad station.

Streams. None of any importance.

Country. Rolling farm land intersected by barb wire and hedge fences.

Camp grounds. None suitable en route on account of scarcity of water in dry weather.

Railroads. The Union Pacific Railroad close at hand at all times after the first three miles.

Telegraph lines. Two wires with usual wood poles.

(Reservation limits.)

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

HEADQUARTERS, 1ST BATTALION OF ENGINEERS,
CAMP LUDLOW, FORT LEAVENWORTH, KANSAS,
SEPTEMBER 7, 1902.

GENERAL ORDERS NO. 75.

Extract.

* * * * * * *

6. Lieutenant N. E. Bower, Corps of Engineers, is detailed as topographical officer.

BY ORDER OF MAJOR LEACH:

H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant.

Near Belvue the south road was taken, passing through Belvue instead of going around it on the north. This road was quite muddy and would be worse than the upper road in wet weather, while it is not appreciably shorter. (See maps.)

Kilmer was not passed through. Instead of turning east when at a point 1½ miles west of Kilmer the command continued north 2 miles, then turned east following the main telegraph line into Meriden. The distance is the same as through Kilmer. The good road from Kilmer to Meriden was sketched by one of the parties and will be involved in the map.

The post was approached from the south road and the engineers' barracks terminated the march.

DIARY.

The command consisted of the four mounted detachments, one escort wagon, the pack train, and the advance guard bridge train. The return trip was made in seven days, covering a total distance of 143.39 miles. The average rate of marching was 20.48 miles. The longest march was 27.16 miles, and the shortest march was 14.74 miles. The only rain encountered en route was light showers at St. Mary's after the command had gotten into camp.

N. E. BOWER,
2d Lieut., Corps of Engineers,
Topographical Officer.

1st Endorsement.

HDQRS. 1ST BATTALION OF ENGINEERS,
CAMP ROOT, FORT RILEY RESERVATION, KANSAS,
SEPTEMBER 25, 1902.

Respectfully forwarded to the Adjutant-General, Maneuver Division, report and itinerary inclosed herewith.

The maps submitted are originals. It has not been possible to reproduce them on account of the dark weather which has prevailed. It is desired to take up the work of reproduction as soon as weather permits, and with this object in view I request the return of these maps as soon as the Commanding General has examined them.

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

559-1902.

Then followed the bridge train, accompanied by Company C as a guard, then the pack train and finally the mounted detachment of one company as a rear and provost guard.

Camps were made on sites determined before the march was begun, and fuel and forage were supplied by local contractors. The sites selected were at Lowemont, Easton, Winchester, Osawkie, Kilmer, Topeka, Reform Farm, Silver Lake, St. Mary's, Wamego, Elbow Creek, and Eureka Lake.

The battalion was rationed at Fort Leavenworth for six days, except the meat component which was for three days. Fresh beef was supplied at Winchester, Kilmer, Topeka, St. Mary's, Wamego, and Manhattan. Six days' rations except fresh meat were drawn at Topeka.

At each camp the battalion was disposed in a rectangle, with one side occupied by the picket line of the mounted detachments.

The camp guard was composed of the picket line guard and one post on each of the other sides. Eight reliefs were mounted, giving each sentinel one tour of about 1½ hours. Each relief was in charge of a non-commissioned officer. On reaching the vicinity of camp the advance guard posted a mounted picket on each road. These pickets were relieved at 2-hour intervals by members of the same detachment until 6 P. M., when the camp guard was mounted, at which time a picket post of a non-commissioned officer and four men was posted on each road, and the mounted pickets withdrawn.. An officer of the day was detailed for duty from 6 P. M. until reveille.

The medical stores supplied for the march were inadequate in variety and quantity. There was not more than enough foot powder for issue to a dozen men. There was no quinine, though it was entered on the list on the lid of the box. There were no liniments. The surgeon telegraphed for quinine and foot powder and these were supplied at Meriden.

The sick report was not large at any time. A corporal of Company D was kicked in the groin by a horse on the morning of the second day and was sent back by train to Fort Leavenworth. He was discharged from hospital on the third day after his arrival and asked permission to join the column. He was authorized to do so at his own expense and rejoined at Osawkie. A corporal of Company B fell over a tent cord at Silver Lake and broke his arm near the elbow. He was sent back by train. One private was missing on the 17th. He was last seen near the well from which water was procured at the dinner halt. He complained of cramps and went through the fence to an adjoining field. He was not missed when the start was made and was not reported absent until after retreat.

Immediately after reveille the next morning an officer was sent back with a wagon and a thorough search was made as far back as the place where the halt was made. No trace of the man was found.

The weather during the entire period of the march was very good and the roads in their best possible condition. The nights were very cold. At Kilmer there was a heavy frost and ice formed. But one day was warm enough to have any effect on the men.

The reconnoissance was done principally by mounted men. An aggregate of about 350 miles of roads were traversed and mapped. All probable alternative routes were explored and all intersecting roads were covered for a mile or more on each side of the main route.

The battalion arrived at the camp of the Division of Maneuvers at 11 A. M., to-day and went into camp. Its present strength is shown by the field report already submitted.

Very respectfully,
SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

526-1902

APPENDIX NO. 3.

HDQRS. 1ST BATTALION OF ENGINEERS,
CAMP ROOT, FORT RILEY RESERVATION, KANSAS,
SEPTEMBER 24, 1902.

THE ADJUTANT-GENERAL,
BLUE ARMY,

SIR: I have the honor to submit the following report of the operations of the 1st Battalion of Engineers during the outpost exercise of to-day.

The mounted detachments of Companies A and B, with a commissioned officer and a pack train of intrenching tools, were sent to report to the Commanding Officer, 28th Battery Field Artillery. The remainder of the battalion, 8 officers and 198 men, with 2 surgeons and 5 men of the Hospital Corps, and 3 company tool wagons, left camp at 8.33 A. M., and marched by the Milk Ranch road to the vicinity of Morris Hill, where the position to be taken was pointed out. It was a commanding knoll between the branches of Forsyth Cañon.

On reconnoitering the position the northern face was found to present four distinct spurs. One company was assigned to the spur on each flank and the largest company was posted near the head of the ravine between the two extreme spurs, with pickets on each. The smallest company was placed in reserve toward the right flank which seemed the most important, and a short distance in rear of the position. It had complete natural cover. On account of ravines intersecting the rear of the position a greater depth of disposition was not practicable.

The reconnoissance of the position, showing the location of each support and picket is herewith.

The battalion was in position and had begun entrenching at 10.01 A. M.

At 1.10 P. M., a few of the enemy's cavalry scouts were seen in front of the right of the position at 800 or 900 yards distance. They were fired on at the range stated and were apparently put out of action.

Aside from this the day was without incident.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

553-1902.

APPENDIX NO. 4.

HDQRS. 1ST BATTALION OF ENGINEERS,
CAMP ROOT, FORT RILEY RESERVATION, KANSAS,
SEPTEMBER 29, 1902.

LIEUTENANT-COLONEL WILLIAM STANTON,
11TH CAVALRY,
COMMANDING ADVANCE GUARD, BLUE FORCES.

SIR: (1) I have the honor to submit the following report of the participation of the 1st Battalion of Engineers in the reconnoissance in force made this day.

(2) The battalion left camp at 8 A. M., under orders to rendezvous at the Pump House Road, near the race track, at 8.45. The strength was as follows:

(3) Companies A, B, C, and D, less mounted detachments of A, B, and D, 6 officers, and 130 men.

Mounted detachments of Companies A, B, and D, 1 officer, and 50 men.

One company wagon with litter and tools. Regimental Field Hospital.

(4) The command reached its position in column on the Pump House Road at 8.30 A. M. Company C, Lieutenant Burgess commanding, was sent forward as support of the advance guard.

Verbal orders were received here from Colonel Rodney to march the command in column on a trail to be pointed out by Lieutenant Canfield, A. C., and not to deploy until ordered to do so.

At 9.15 the battalion, forming the reserve of advance guard, moved out as indicated. The march was continued from the cañon under cover of

Captain March I was directed by him to place my company on the left of his battery as a support. In accordance with this order the company was posted in line of skirmishers on the military crest to the left of the battery, the left of the company being slightly refused so as to bring fire to bear against a flank attack.

When the battery was limbered up to move forward from Morris Hill the company was assembled and put into column of march following the battery. But at this juncture Lieutenant Canfield, acting as aide to Colonel Rodney, directed that I should remain on Morris Hill and act as support to the 28th Battery, which was advancing to this position. This order was obeyed. It was impracticable at this time to communicate the substance of this order to my immediate commander, Captain March, but this was done at the first opportunity.

After the 19th Battery had come into action on the hill to the east of Morris Hill, I received an order from Captain March (by orderly) to bring by company up on the left of his battery. I reported this order to Colonel Rodney, and was directed by him to comply with the same.

I immediately moved forward the company in double time on the line of and to the left of the 19th Battery, breaking the company into line of skirmishers before reaching the crest of the hill. Upon the appearance of my company on the crest of the hill, a few of the Brown Cavalry scouts, who had been observing the battery position from a point to the left front about 800 yards from the battery, fell back to the next ridge, out of range.

Upon direction of Captain March the company was advanced to the left front of the battery, so as to command the valley running at right angles to our front.

A small knoll about 200 yards to the left of my line entirely obscured my view toward the north. For this reason I posted a picket on the crest of this hill. This picket about 11.15 reported the advance of a Brown Cavalry patrol. I took one section of the company and gained the crest of the knoll at the double time, just as the cavalry patrol of about 12 men reached the crest of a ridge about 600 or 700 yards distant. Two volleys were fired, kneeling, at 600 yards, at this patrol, whereupon it retreated. I left this section posted on the knoll, then returned to the company. I had hardly returned when the Brown Infantry, in skirmish line, appeared on ridge about 1,000 yards away. Sights were set for 800 yards and when the enemy had advanced to this distance six volleys were fired before he had moved forward a hundred yards. A much heavier fire could have been delivered had ammunition been plentiful. When these volleys were delivered the Brown line was silhouetted against the sky, while my line was screened by the grass at the edge of the trail in which the company was posted. For this reason it seemed apparent that the enemy must have suffered heavily from this fire. At this stage cease firing was sounded, but the Brown force on the left (right of his line) advanced about 200 yards, firing as they advanced. No reply was made.

Meanwhile the cavalry patrol appeared again on the left, and was driven back by five volleys from the detached section at 600 to 700 yards range.

This ended the operations of the company, as it was marched off when recall was sounded.

Very respectfully,
HARRY BURGESS,
1st Lieut., Corps of Engineers,
Adjutant, 1st Battalion of Engineers,
Commanding Company C.

575-1902.

APPENDIX NO. 6.

CAMP ROOT, KANSAS,
OCTOBER 7, 1902.

THE ADJUTANT-GENERAL,
MANEUVER DIVISION.

SIR: I have the honor to submit a report of the action yesterday in accordance with Problem No. 10.

The problem was to occupy and hold a defensive position to prevent a strong Brown force of all arms from reaching Fort Riley. The force under my command consisted of the 1st Battalion of Engineers, less one company; 6th Regiment of Infantry; A Troop, 8th Cavalry; 6th and 28th Batteries, Field Artillery.

The field hospitals of the Engineers and Infantry were with their respective organizations. Captain Wilson, Medical Department, reported as Chief Surgeon, and Captain E. B. Ives, Signal Corps, as Chief Signal Officer. Captain Ives furnished men and means of prompt and efficient communication with all parts of the position.

The line of defense selected rested its right on One Mile Creek, ran along the ridge upon which the reservoir and Ogden Monument stand, and continued in prolongation of this ridge across the gorge of Republican Flat, resting its left on Republican River. The disposition of forces made is shown in the order issued, a copy of which is herewith. All details of disposition were left to the subordinate commanders and officers named in the order. I rode over the right and center positions just before the action began and found everything in satisfactory shape. I did not find it necessary to make the slightest change.

The troops were in position a few minutes after 7 A. M., and shortly after 9, men and guns were well intrenched.

The instructions for fire regulation are given in the order and were carefully followed by the subordinate commanders, except that the two guns on the right replied to artillery fire from Morris Hill, which was not contemplated in the order.

The action on the right was opened at 10 A. M., by a battery of artillery from Morris Hill. This battery displayed a red flag from which it would appear that it had an artillery target. No guns of the defense had as yet opened and Brown scouts had been within 150 yards of the right artillery position without suspecting its presence. The infantry attack was developed a few minutes later, large bodies advancing in close order and infantry marching by the flank in plain view of the Blue lines. The only alternative suppositions are that the Brown did not suspect the proximity of the Blues or entertained a supreme contempt for their prowess. I adopt the former. This attack beginning on the right was developed to our left until it enveloped right and center with a thin and much exposed line.

At 11.15 A. M., I received information that the two guns on the right were out of action. I at once ordered two guns of the 28th from the center to replace these and also ordered two guns of the 6th to the right, intending to use them in case the mountain guns were late in arriving. The two guns of the 6th were in position ready to open when cease firing was first sounded, and the two mountain guns were unpacked, on their wheels, and ready to be run into the pits, when the action ceased on the right.

In the center the foot troops fired frequently at excellent targets at mid ranges. The four mountain guns on the left of the center were kept busy firing at excellent targets at close artillery ranges. The commander of this battery allowed a skirmish line of dismounted cavalry to march past the Pump House, to avoid a premature disclosure of his position, knowing that they were walking into a trap.

The work on the left was not under my observation, as I could not get to that part of the line during the action. The reports of subordinate commanders show that it was extremely interesting. Everything which appeared on that front was ruled out of action except one man of a cavalry troop whom the umpire, after a special intercession, allowed to go back with news.

The means of communication between the several parts of the position were left entirely to the Chief Signal Officer, Captain Ives. The dispositions were explained to him and he was left to make such arrangements as he saw fit. He saw fit to make them most complete and effective, including a telegraph station on Morris Hill, which was in operation during the entire action.

The work of the cavalry patrol was most satisfactory. Prompt and clear reports were sent back almost from the time the troops left the position. On one occasion I was completely encircled by couriers, each waiting to hand me a report. At no time was I in the least doubt as to the enemy's disposition and movements.

When the action was suspended, in addition to the guns heretofore alluded to, there were two companies of infantry and a troop of dismounted cavalry in reserve which had not been under fire.

I invite particular attention to reports of subordinate commanders attached hereto. They present many details without which the progress of the fight can not be fully understood, but which I am not able to incorporate in this report.

The profile adopted for infantry trenches is that usually known as "kneeling trench." The trench is four feet wide on top, three feet on the bottom, and one-and-a-half feet deep. The parapet is one-and-a-half feet high and two-and-a-half feet thick on top. Men in this trench are secure from shrapnel fire and if lying on the bottom are also safe from shell, which must pass through six to ten feet of solid earth to reach them.

The conduct of all the troops under my command deserves the highest commendation. The reservation of fire was especially commendable. The zeal and enthusiasm of the officers and the interest and attention of the men would not be greatly exceeded in actual battle.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding Blue Forces.

591-1902.

APPENDIX NO. 7.

FORT LEAVENWORTH, KANSAS,
OCTOBER 27, 1902.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS.
(Through Commanding Officer, Company A.)

SIR: I have the honor to submit herewith my report of the work done by Company A, 1st Battalion of Engineers, at the Fort Riley maneuvers.

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers.

FORT LEAVENWORTH, KANSAS,
OCTOBER 22, 1902.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS.
(Through Commanding Officer, Company A.)

SIR: In compliance with Circular No. 7, Headquarters 1st Battalion of Engineers, Fort Leavenworth, Kansas, October 18, 1902, I have the honor to report as follows concerning the work done by Company A at the Fort Riley maneuvers.

Corporal Charles Lowenheimer and 1st Class Private Alvah H. Mitchell were on special duty as assistants to the maneuver division topographical officer from September 22 to September 26.

2d Class Private John Howry was on special duty as draughtsman September 23 to October 8.

Hydrographic survey of Kansas River. Five cross sections about 300 feet apart were sounded every 10 feet. The resulting notes have been plotted and the plot and a report upon this work have been submitted.

A copy of the above-mentioned report accompanies this report as Appendix A.

On September 23, the mounted section took part in a drill of the mounted company, pack train and bridge train combined.

On September 24, the company, except the mounted detachment, took part with the battalion on outpost duty as a part of the Blue Force, the company as battalion reserve. The company, by direction of the Adjutant, took up a position in close order in a sheltered position and accessible to the different parts of the line of the battalion supports and remained there until the close of the exercise.

The mounted detachment of the company with pack train was directed to report to Captain Charles T. Mencher, Field Artillery, at his camp.

It accompanied him to Sheridans Bluffs, where the work of intrenching the battery was given it. The mounted detachment of Company B was united with that of Company A on this day, all under command of Lieutenant N. E. Bower, Corps of Engineers. The non-commissioned officers laid out the gun pits and took immediate supervision over the work of digging them. The privates started the work of digging and later alternated with the enlisted men of the 28th Battery in digging. These pits were completed in about an hour and a half. Lieutenant Bower then reported to Captain Mencher for further instructions. He was referred to Colonel Miller, 22d Infantry, who was commanding the right of the line, who said he had no intrenching to be done and directed Lieutenant Bower to join the supports acting as infantry. As the principal attack was made on the left of the line, no active part was taken by any of the troops on the right.

The pit constructed was the German gun pit, the width of the gun portion reduced to 10 feet and not dug.

On September 26, I was directed to report with one platoon to the commanding officer of the 6th Infantry, to take part in an advance guard exercise. The platoon was accompanied by one escort wagon, carrying tools for intrenching and for bridge construction. These tools were not called for during the day. A copy of the report submitted to 1st Lieutenant James B. Kemper, 6th U. S. Infantry, acting as adjutant of the column, accompanies this report as Appendix B.

Lieutenant N. E. Bower, commanding the other platoon, reported to Lieutenant-Colonel Adams, 18th Infantry. The assembly was made at the hay sheds, at which place Lieutenant Bower reported to Colonel Adams, 18th Infantry.

One section of the mounted detachment with pack train was assigned to the support of the advance guard, one section with wagon to the reserve. After the advance guard had moved forward some distance, the enemy was encountered and very soon the support was put on the firing line. In the absence of orders Lieutenant Bower turned over the horses to the horse holders, and they with the pack train were left in a protected place while the rest of the detachment was taken to the right of the firing line and advanced with the firing line, now almost a mile long, in the direction of Morris Hill. Before reaching this place the engagement terminated. The second section, under Corporal Jacoby, was not engaged. After lunch at Morris Hill the rear guard formation was taken up and the platoon was assigned to the reserve.

September 27. The company, except the mounted section, took part in the exercises of the day with the battalion under the direction of the Battalion Commander. When the battalion left the Governor Harvey Road to ascend the hills to the right, the company was left behind to assist in getting the bridge train up these hills. A muddy portion of the road was repaired by throwing in rock of which a large quantity was available in the immediate vicinity. Each wagon was assisted up the first hill by a squad of men and no further difficulty was encountered for about a quarter of a mile, when the tool wagon upset. The wagon was righted and the contents piled therein and the train proceeded without further mishap.

The company joined the battalion about 12 M.

The mounted detachments of Companies A and B were united under command of Lieutenant Knight, Lieutenant Bower being second in command. The two detachments with their pack trains were assigned to the reserve of the advance guard. The absence of orders was very conspicuous at this time for they were left totally in the dark as to their functions and they rode with hospital wagons in front of and behind them until quite near the firing line. Here they were dismounted to fight on foot and joined the firing line just as the engagement was ended.

September 30. The mounted section, 5 non-commissioned officers and 21 privates dismounted section in conjunction with a detail from Company D, completed in the forenoon the construction of the approach to the ponton bridge on the south bank of the Kansas River.

The first three days of October, 2 non-commissioned officers and 12 privates were on duty under the orders of Captain C. A. F. Flagler at the ponton bridge.

Drills were had on October 1 and 2 in the construction of low and high wire entanglements for such men of the company as were available.

October 6. The company took part with the battalion as a part of the Blue Force.

A copy of my report of operations on that date to the Adjutant-General, Blue Force, as engineer officer in charge of the intrenchment of the center of the line of defense is appended (see C.)

This report includes in a general way the operations of the company.

From the right of the five squad trenches of this company, Lieutenant Bower had command of the first and second squads, I had command of the third and fourth, and Lieutenant Frazier the fifth. No firing was done at a greater range than 600 yards, and the firing at individual scouts of the enemy and at small squads was individual, volleys being fired when the enemy appeared in sufficient force at the short ranges to justify it.

October 7. The company with the exception of the mounted detachment took part in the exercises of the day, with the battalion acting as a part of the Blue Forces.

From 10.15 to 11.30 A. M., the company acted with Company B as a support to the 20th Battery, Field Artillery.

These two companies then joined the Battalion Commander and Company A acted as battalion reserve, while the Blue line was forming, keeping 400 paces in rear of the battalion supports and on its left flank. The company was then put on the line at the extreme left of the Blue Force, with the exception of the Engineer Mounted Company, which position it held until the close of the exercise.

The three mounted detachments were united under command of Lieutenant Pope, Lieutenants Knight and Bower commanding platoons. Later a detachment of about 12 men of the 8th Cavalry reported to Lieutenant Pope. Advance guard was formed with these mounted men in a deep ravine. Before it was entirely formed the flankers were engaged. Lieutenant Bower requested a patrol of Lieutenant Pope to round up stray parties of the enemy. This was given and he moved forward with the patrol on the enemy's left. The small parties anticipated proved to be the enemy's firing line. Lieutenant Bower being directly on the flank of this line dismounted his small patrol and enfiladed the line as it retreated. After moving back about 800 yards the firing line had developed considerable strength. Here three volleys from a battalion was drawn, besides obtaining good shots at the enemy's officers. Lieutenant Bower rode back and gave the information to the advancing line, meanwhile leaving the patrol under command of the sergeant in a secluded place. When he returned the patrol had been ruled out by an umpire. Lieutenant Bower then joined Lieutenant Knight, operating with his mounted detachment and part of A and B companies on the enemy's right. After getting on the rear of the right of the enemy's line an umpire notified Lieutenant Bower that the detachments were ruled out. This terminated the operations of himself and detachment for the day.

October 8 at 4 P. M., all available enlisted men of the company were reported to the Commanding Officer, Company C, for duty during the exhibition exercise of the dismantling and reconstruction of a portion of the ponton bridge.

To Company A, Engineers, was assigned the work of adding a 3-mile border to maps of the reservation already existing. Lieutenant Bower was directed to take entire charge of this work and it was pushed as rapidly as possible. Two unforseen circumstances materially delayed this work In the first place it was difficult to attach our road sketches to these maps as they had been compiled from information gotten from various sources and in many cases the roads were incorrect. Then again the weather was rainy, rendering the roads so muddy as to be almost impassable.

Permission was gotten from the Adjutant of the battalion to start from the interior of the post and work outwards. Both mounted and dismounted men were used for the work. In order to make the interior work more accurate the Water Tower, Morris Hill, and Sheridan's Bluffs were located by triangulation, using a paced base line, and bearings were taken from these to other points. The work was then carried on as far as time would permit. No effort was made to make a map of the post proper, as good maps of this already existed. The result of the work was traced and blue prints have been submitted.

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers.

1st Endorsement.

FORT LEAVENWORTH, KANSAS,
OCTOBER 27, 1902.

Respectfully forwarded to the Adjutant, 1st Battalion of Engineers.

THOMAS H. REES,
Captain, Corps of Engineers,
Commanding Company A.

CAMP ROOT, FORT RILEY, KANSAS,
SEPTEMBER 26, 1902.

1ST LIEUTENANT JAMES B. KEMPER,
6TH UNITED STATES INFANTRY.

SIR: I have the honor to report the following operations of the first platoon, Company A, 1st Battalion of Engineers, this date.

Having been informed by the advance guard commander that the 6th Infantry would assemble at 8.30 in its camp, and pursuant to his instructions that the platoon would join that organization as it passed the camp of the 1st Battalion of Engineers, it was directed that the platoon fall in at 8.30 A. M., so as to be prepared to join at 8.40 A. M.

The 6th Infantry passed at 8.22 A. M., and I was directed by the Adjutant to join the 6th Infantry as soon as possible at the Pumping Station. The platoon left camp at 8.35 A. M., and was reported to the advance guard commander 9.10 A. M. I was directed to lead the reserve with the platoon. At about 11 A. M., the platoon was ordered on the firing line. It advanced about 800 yards in extended order to a line 15 yards in advance of the battery and on its left. It there opened fire on the Brown in extended order about 600 yards distant. After one volley, the order to cease firing was received.

On the return march, as a part of the rear guard in retreat, the platoon was assigned to the reserve and placed at its head, a position it held until the rear guard was attacked, which occurred after the platoon had entered the north end of the gully on the Governor Harvey Road north of its intersection with Milford Road. The Infantry and Artillery of the reserve were withdrawn. When firing began on our right and in our advance, I moved the platoon to an advantageous position near the south extremity of the gully, with a view of resisting an attack from that direction. The platoon occupied this position until recall. The platoon commander then reported to the rear guard commander and was directed to return to the engineer camp with his platoon.

A sketch of the route of march and sites of engagements was made by Corporal Philgren, Company A, 1st Battalion of Engineers, and he was directed to submit the same to the Commanding Officer of the column.

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers,
Commanding First Platoon, Company A, 1st Battalion of Engineers.

CAMP ROOT, FORT RILEY RESERVATION, KANSAS,
OCTOBER 6, 1902.

THE ADJUTANT-GENERAL BLUE FORCES,
CAMP ROOT, FORT RILEY, KANSAS.

SIR: I have the honor to report the following intrenchment of the center of the line of defense this date, under my direction.

The general plan adopted was the standing trench and such further thickening of parapet, without deepening trench, as time would permit.

The trenches were for squads, proper provision being made for containing such file closers as might be assigned to squads, flanks being generally refused. The center occupied four ridges, separated by ravines, opening to the west into Pump House Cañon, on a general north and south line from Milk Ranch Road to Ogden Monument.

1st ridge. Five squad trenches in echelon, occupied by Company A, 1st Battalion of Engineers, 52 strong.

2d ridge. Two squad trenches occupied by one platoon, 1st Battalion of 6th Infantry, 14 strong.

3d ridge. Three squad trenches occupied by one company, 1st Battalion of 6th Infantry, 30 strong.

4th ridge. Four gun-pits, occupied by guns of the 28th Battery (Mountain). On the south slope of this ridge was intrenched the artillery support. This ridge was intrenched under the immediate supervision of Lieutenant N. E. Bower, Corps of Engineers. Lieutenant Bower, the mounted detachment, and all non-commissioned officers of the company engaged in supervising intrenchments for the infantry joined the company at 10 A. M., and took their places in the trenches.

All the trenches made for foot troops were on soil closely underlaid with solid rock. A modification of the standing trench was therefore made, and with the exception of the second ridge, by a trench very similar to the regular kneeling trench, a thicker parapet being, however, generally obtained. On the second ridge directions were given and later directions for necessary modifications; these directions were misunderstood and a parapet, or rather a stone wall, was built mostly in elevation to a height of about four feet, thus affording a good target for the enemy.

This was not a key point, very weakly held, its occupancy not essential and though not intended, I am of the opinion that making this parapet prominent was a fortunate occurrence in that I noticed the enemy's fire constantly directed toward it, and to the advantage of that part of the line which was occupied in stronger force.

All trenches with the above exception were well concealed in with grass, cut and placed, and as long as Company A, Engineers, remained in their trenches, I am confident that the enemy had not located its trenches, and were ignorant of the fact that their lines were being fired upon by our men sheltered only 300 to 500 yards distant.

The final attack of the enemy was made against the position held by this company, and consisted of a line of skirmishers followed by other lines of supports and reserve. This entire force was under fire as above for about ten minutes. The company was then ordered forward from the trenches by Major Morton, 6th Infantry, to the military crest for the purpose of firing upon those of the enemy who had advanced toward us over the military crest of the hill in our front. The company was at once brought back to the trenches. Probably the enemy opposite to it were out of action before the company left its trenches and the company was under no other fire before it returned to the trenches.

A sketch of the positions occupied by the center and the location of the intrenchments accompanies this report.*

Very respectfully,

H. W. STICKLE,
1st Lieut., Corps of Engineers,
In charge of trench construction for the center of line of Blue Forces.

Enclosure.

HDQRS. COMPANY B,
1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS, OCTOBER 23, 1902.

THE ADJUTANT, 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS.

SIR: In accordance with Circular No. 7, Headquarters 1st Battalion of Engineers, Fort Leavenworth, Kansas, October 18, 1902, I have the honor to make the following report:

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* Not printed.

The work done by Company B at Fort Riley during the period of the maneuvers was as follows:

September 20, 1902—

Making camp.

September 21, 1902—

Sunday.

September 22, 1902—

Constructing a road and bridge across the gorge of One Mile Creek, leading from the main road northeastward to the Field Hospital.

September 23, 1902—

Same as September 22.

September 24, 1902—

Formed part of Blue outpost of an army corps. The support intrenched itself with tools carried in army escort wagon.

September 25, 1902—

Cutting timber for double-lock spar bridge, and worked on road begun on the 22d instant.

September 26, 1902—

Company assisted Company C in constructing ponton and trestle bridge and corduroying approach thereto.

September 27, 1902—

Participated with the Battalion of Engineers on Blue advance guard for a division of full strength.

September 28, 1902—

Sunday.

September 29, 1902—

Participated in problem of contact of forces of all arms.

September 30, 1902—

Collecting materials for spar bridge and loading ponton bridge material on wagons.

October 1, 1902—

Same as September 30.

October 2, 1902—

Same as October 1.

October 3, 1902—

No work.

October 4, 1902—

No work.

October 5, 1902—

Sunday.

October 6, 1902—

Formed part of Blue defensive line in problem of attack and defense of a position.

October 7, 1902—

As Blue infantry in tactical exercise for a division.

October 8, 1902—

Assisted in dismantling ponton bridge. Began construction of double-lock spar bridge over gully just east of Three Mile Creek.

October 9, 1902—

Completed spar bridge and dismantled it.

October 10, 1902—

Entrained for Fort Leavenworth and arrived there at 5.20 P. M.

* * * * * * *

With reference to the matter of equipment, I believe the maneuvers at Fort Riley demonstrated again the necessity for an infantry intrenching tool. In moving infantry in an open country or in holding a position suddenly attacked, it is absolutely necessary for infantry to intrench, and this can only be done satisfactorily with a tool carried on the person of the infantryman. It is not to be assumed that engineers with tool wagons or pack trains will be present with all forces of troops, and even if they were present the distribution and collection of tools before and after the intrenchments are made, present such practical difficulties that nothing but the tool carried on the person can be safely relied upon.

There is no difficulty in carrying tools in wagons to be used in positions which are to be fortified and held for a lengthy period. The same may be said of tools in pack trains, but as yet the Engineer Department has not devised or adopted a pack train outfit, nor has the question of the kinds, sizes, and quantities of the various tools to be carried in wagons or pack trains been decided. The experience gained by the battalion at Fort Riley in that direction was so meagre, in my opinion, that it is of little value in determining these questions. I would recommend immediate purchase of an English pack train outfit for experimental purposes.

The equipment of the engineer soldier is satisfactory, except that the carbine should have a strap-sling and a stacking-swivel, so that it may be carried over the shoulder, thus leaving both hands free as well as making the piece easier to carry on the march, and so that the pieces can be placed in an orderly arrangement on the ground when not in use.

The road and bridge work executed by Company B was of such a nature that no new points were brought out with reference to the Engineer equipment. Where extensive and rapid road work is to be accomplished, use may be made of modern inventions for road work, obtained from the nearest commercial supplies, rather than in attempting to carry such articles with the army in the field, whose main reliance will always be upon the pick and shovel alone.

Very respectfully,

GEORGE A. ZINN,
Captain, Corps of Engineers,
Commanding Company B.

COMPANY C, 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS,
OCTOBER 28, 1902.

THE ADJUTANT, 1ST BATTALION OF ENGINEERS,
PRESENT.

SIR: I have the honor to submit the following report of the work performed by Company C of the battalion during the recent maneuvers at Fort Riley, Kansas, and the journey to and from the maneuvers.

The advance guard ponton train was assigned to Company C by the Battalion Commander prior to the march to Fort Riley. The train consisted of eight ponton wagons, one tool wagon, two chess wagons, and two trestle wagons fully equipped (the forge wagon was shipped by rail). These wagons had been modified for hauling by the removal of the splinter bars and the substitution of double and single trees for four mules. Brakes were also attached to the rear wheels of all except the tool wagon, for use on gentle grades where locking the wheels would be inadvisable; these brakes were operated by the teamster from his saddle on the near wheeler by a line attached to a brake lever of ordinary form. The harness used was that known as jerk line harness. The teamsters were all civilians.

The wagons stood the march to Fort Riley fairly well; the brakes proved difficult of operation from the saddle and were generally operated by a man riding on the wagon for the purpose. I am convinced that the double tree attachment is much better for the purpose than the splinter bar. The jerk line harness is, however, objectionable, it being very difficult to prevent the mules, on turning to the left, from turning too short. I should recommend the adoption of four line harness, with the teamster riding on the wagon; this would also facilitate his working the brake.

Several front bolsters on the wagons broke and one wheel, due to dry rot in the wood; one locking-chain also broke.

The country crossed was not difficult; the weather was fair with little mud. From Leavenworth to Topeka rolling country, with fairly steep hills; from Topeka west, generally level roads with some heavy sand.

The company, which was formed almost entirely of recruits assigned in June, 1902, had had little practice in ponton work, only the month of August being devoted thereto. Exercises were had during that month in knots and lashings, in boat and flotilla drill, construction of ponton bridge with reserve equipage, construction of trestle bridge on land and water, and assembling of advance guard pontons on land. The assignment to to the advance guard train occurred too late for any practice with it upon the water.

The composition of the company when it left Fort Leavenworth was as follows: One captain, six sergeants, eight corporals, two cooks, one acting musician, twenty-nine first-class privates, twenty-three second-class privates. The captain, one corporal, the acting musician, and four privates were mounted. One 2d lieutenant joined the company October 1 and one corporal and one private were sent to Fort Leavenworth sick. The average daily sick during the march and maneuvers was 1.4 in quarters, 1.0 in hospital; on the march the average was .66 in quarters, and none in hospital.

On the march the company was formed on the train as follows: The men in heavy marching order were assigned by squads to certain wagons, deposited their blanket rolls upon the wagons and marched beside them on each side in column of files carrying their carbines and other equipments. They gave assistance in locking wheels, handling brakes, and correcting position of loads when necessary. Each squad remained under charge of its corporal who was responsible for its discipline on the march. The sergeants were distributed along the train and exercised general supervision. A mounted corporal carrying the company guidon rode abreast of the leading wagon. The company commander rode at the rear of the train followed by the musician and the remainder of the mounted detachment acting as orderlies.

The rate of moving of the column as determined by the record of September 10, taking into account all stops, was as follows: 3.11 miles per hour, actual marching rate. With the ordinary ten-minute halt every hour this would become 2.49 miles per hour. The remaining companies of the battalion marched just in front of the train and numerous extra stops were made on account of this slower rate of march. The actual rate on September 10, including all these stops, was only 2.1 miles per hour. This continual halting was rather wearing upon the men and mules, but was largely corrected by the orders of the Battalion Commander for the wagon train to leave camp each morning twenty minutes after the foot column. On September 11 these rates were 3.47 actual marching rate, 2.97 with ordinary stops, 2.24 including all stops; one, a dinner halt of one hour and twenty-eight minutes.

Several small bridges over road drains broke under the train during the march but nothing of any consequence. On two occasions a few chess were used to floor over breaks but nothing more was necessary.

The command arrived at Fort Riley on September 19 and encamped about a quarter of a mile to the northeast of the artillery post. The journal of operations at Fort Riley is as follows:

September 19 and 20. Setting up and ditching camp, digging sinks, etc.

September 21—Sunday. Made inspection of river with a view to throwing ponton bridge across. General Bates having expressed a desire to have bridge debouche about the middle of the Smoky Hill Flats, south of the Kansas River, I selected a site opposite the dumping ground south of the railroad station (shown on map herewith).* This was the only point opposite the flats that possessed a road leading through the woods and obviated any further search. The sand bar shown on map was about three feet above water, and it was my design to utilize it to shorten the bridge so as to avoid the use of trestles. The Battalion Commander approved the site selected.

September 22. Launched three wooden pontons at lower ford, three-quarters of a mile below bridge site. One of these was taken up to site, other two turned over to Lieutenant Stickle for hydrographic survey of river.

Cleared brush from road leading to site, cut fifty yards new road around dump pile which was too soft for passage of animals.

Cut approach through north bank to level of sand bar, cut nineteen logs for corduroy. Tried to blast down approach on south shore; fired two blasts of one and three pounds of dynamite, respectively, with little effect, material being sandy loam; no blasting powder was available, so this method abandoned. Stopped at 4 P. M., owing to rain.

September 23. Drizzling rain in the morning; company engaged in equipping reserve train with anchors, cables, lashings, etc. In the afternoon weather cleared and company began work at bridge site, cutting approach on south bank and corduroying road on sand bar. Stopped work at 2 P. M., owing to heavy rain.

September 24. Company took part in maneuver representing attack on the outpost of a division, the Battalion of Engineers being a portion of the outpost. The battalion left camp at 8.30 A. M., marched to Morris Hill, and then east along ridge running to Sheridan Heights. Company C was assigned to center of battalion line and its position indicated by the Battalion Commander along this ridge. I selected a position on military crest of ridge for the company in support and sent out four cossack posts on points of ground projecting into the ravine in the north and connecting with the posts of Company D on my left, company tool wagon delivered tools and intrenching began (theoretically only) at 10.21 A. M., dug kneeling trenches to 11.20, then lying trenches about fifty yards on either flank in case line of resistance should be broken. About 11.30 discovered Company B had moved forward to a position on my right front and was overlapping my cossack posts. I shifted the posts to the left and front to make the line continuous and moved the company to a new position about 100 yards to the left front of its original one, as orders had been issued to remain concealed after 12 M., the men lay in the grass and further intrenching was not resorted to.

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* Not printed.

Heavy firing was heard to the left and some musketry to the right, but no enemy was seen. At 2.30 P. M., the cossack posts were relieved and at 3 P. M., recall was sounded and the command marched back to camp.

September 25. River had risen considerably, cutting through bar next to north bank. Built a log and brush dam and corduroyed with brush and logs 130 feet of road, 10 feet wide on bar. In the afternoon a further rise of 12 inches cut around the dam, and showed the use of the bar to be very precarious. Selected new line of crossing which was that finally used; sextant measurements showed it 470 feet between sills. The reserve ponton material contained only 17 pontons, so it was decided to use seven trestles, leaving one boat as a guard boat. Reported to the Battalion Commander that the operation required more than one company and he ordered details from other companies to assist on the following day.

September 26. Sergeant Hurtt, with Company C, hauled eight pontons to lower ford, launched them, and endeavored to row up the river but failed owing to heavy current and strong down stream wind. Half of Company B, under Sergeant Neid, cut road (shown on map) to new bridge head and corduroyed about half of it.

Company D began work on south approach with picks and shovels and about half completed it. Set a river gauge in old approach on north bank.

September 27. Sergeant Hurtt with twenty men (all available) unloaded remaining six pontons at south approach, launched them, and moored them on the north bank. In the afternoon hauled balk and chess to the bridge site. The poor appearance of many of the balk caused suspicion as to their strength, and the Battalion Commander ordered them all tested before use. I began testing them in the afternoon, using the following rough method: Two abutment sills were laid upon the ground parallel and twenty feet between their inner edges. Each balk was laid across the sills, then six men each laid a chess at right angles to the balk, three on each side, their ends touching on the balk, other ends on the ground; each man then mounted his chess standing as close together as possible over the middle of the balk. The deflection caused by this weight was obtained by measurement before and after. Calculation showed proper deflection for entire load of 1,100 pounds (six men and three chess), on 20-foot span to be 3.02 inches. All balk showing four inches or more were rejected.

September 28—Sunday. The company brought all boats to the bridge site, eight from lower ford, two which had been used for survey from the Highway Bridge.

September 29. The company went out on maneuver under command of Lieutenant Burgess. With a detail of eight men I tested remaining balk.

September 30. Detail from Company D finished south approach.

Detail from Company B loaded material at depot; Company C constructed seven trestle bays from north approach. These bays were all rope-braced, as shown in sketch herewith.*

Seven balk were laid in each bay for greater strength, the additional balk being placed between the outer ones on each side. It was later shown that under the passage of horses the deflection of the middle balk causes greater jumping of the chess, frightening the animals Placing the additional balk adjacent to the middle balk would diminish this jumping and I should so arrange them in the future.

The footing to the trestles scoured out very rapidly, causing settlement amounting in cases to over two feet. To correct this the caps were raised with a block and fall.

Large masses of drift began running in the river, mostly small stuff, but containing occasional large trunks (largest measured two feet, seven inches in diameter). To protect against the shock of these a 75-pound anchor was dropped twenty yards upstream from each trestle and the cable drawn tight to the upstream leg leading through the slot in the upstream end of the cap; large logs brought up fairly gently on this cable instead of striking legs.

A guard of twelve men and one non-commissioned officer was put on the bridge in the afternoon and retained there until the bridge was finally removed. One sibley tent and stove were set up near north approach for use of guard. Orders for bridge guard are appended hereto.

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* Not printed.

October 1. Company C, with detail of twelve privates and two non-commissioned officers from each of the other companies, began construction of the bridge at 8.45 A. M., completed 12 M.; sixteen bays with boats, making twenty-three bays in all; total length between sills, 448 feet.

The men were distributed as follows:

	Non-commissioned officers.	Privates.
Three upstream anchor detachments	3	12
Cable men	2	
Balk lashers	2	8
Balk carriers	1	14
Side-rail carriers	1	4
Side-rail lashers		2
Chess carriers	1	22
Total	10	62
Superintending boats	1	
Keeping bridge free of drift	4	12

The need of pointed log-hooks was much felt in handling drift as hardly any holding could be secured with the boat hooks.

October 2. In spite of the efforts of the bridge guard who had worked almost the entire night, three large accumulations of drift were found on the bridge in the morning. Two anchors had been carried away by drift and a hole punched in one ponton above the water line. One balk was broken and two trestle legs. Sixth trestle was sunk by drift and scour so that roadway was partially under water. Dismantled three bays and cleared out the drift. Built trestle raft, reset fifth trestle and tried to reset sixth but had not sufficient long legs and short ones would not hold. Decided to use only five trestles and utilize the remaining two boats which had been intended for guard boats. Dismounted trestle raft, and rigged one boat as rope ferry for use of guard across opening.

October 3. Very cold and rainy, did not take company out; bridge guard worked from 8 to 10 clearing away drift from trestles. Lieutenant Ralston went to Junction City and hired a skiff for use as guard boat during passage of troops.

October 4. Rapidly rising river, endangering trestles. Took all of Company C, and one officer, two non-commissioned officers, and twelve privates from Companies A, B, and D, each. Dismantled trestle portion of bridge; the river was over the bank doing some damage to corduroyed road and compelling the men to work knee deep in water. Dismantled south shore bay, to give easy motion to bridge on rise, and sent guard tent to south bank.

October 5—Sunday. No work.

October 6. Constructing trestles again, using five; river had fallen considerably. Completed bridge in the afternoon using all the boats (17) and shortening two bays. Moved guard back to north bank. Signal Corps put telephone in tent connecting with Battalion Headquarters.

October 7. In the morning repaired road where damaged by flood. Cut south approach to new water level.

In the afternoon received word that the infantry would cross bridge about 2 P. M. The infantry arrived at 3.30, crossed the bridge in column of twos and returned in the same formation followed by two squadrons of cavalry and two field batteries that had crossed to the south bank by the Highway Bridge. The Signal Corps automobile, weighing 2,500 pounds, with five passengers, also crossed and recrossed the bridge. The company was distributed two men in each boat to assist bridge guard in enforcing rules; those in the sterns of the boats were equipped with boat hooks and lines to assist any who might fall off the bridge. A member of the guard was in the guard skiff on lower side of bridge ready also to go to the assistance of anyone who might fall in the water.

No breaks of any kind occurred except one chess, which broke under the weight of a horse. It was plainly rotten and was promptly replaced with only one minute halt. The column was halted again for a minute and a half to replace a few chess that worked out from under the side rail on the midstream saddle bay.

After the crossing, three bays were dismantled and reconstructed as an exhibition.

October 8. Companies C, D, and A dismantled bridge in the morning and loaded three pontons on wagons. In the afternoon Companies A and D worked at the railroad depot loading material on train. Companies B and C at the bridge site. All the remaining pontons were loaded and all other material except seven wagon loads. The pontons were loaded by the method of excavating trenches for the wagon wheels about eighteen feet from the bank. The boats were brought stern first to the bank with a cable attached to the two stern posts and led out over the wagon. The bulk of the men heaved on this rope, a few guiding the boat and placing rack sticks for rollers. Sergeant Hurtt directed this loading, and after the first three boats the average time of loading, including unhitching and hitching mules, was six and one-third minutes, with balk already on wagon; eight and one-half minutes when balk had to be placed on wagons.

October 9. Finished loading at both bridge site and depot.

October 10. Returned to Fort Leavenworth by rail.

RECOMMENDATIONS.

The experience with both trains leads me to suggest the following:

1st. That all wagons be equipped with single and double trees and brakes, and that the teams be driven with lines from the wagons.

2d. That one of the boat hooks prescribed for each ponton be made sharp on hook and point similar to log hooks, for convenience in handling drift.

3d. That each ponton company be equipped with twelve oil skin coats and hats and twenty-four pairs of fishermen's rubber boots.

4th. That a suitable block and fall with slings be provided for use in raising and lowering trestle caps, without dismantling bridge.

5th. That the top of the trestle leg be modified in form to stand the continued blows of the maul without brooming and splintering. When the trestles are wet the legs show a tendency to jam in the caps and require a great deal of driving.

6th. To supply four false legs with each trestle.

7th. That each division of the reserve guard equipage should be supplied with a small boat for general work, soundings, life saving, etc. It should be of a size to be carried in one of the ponton boats. I should recommend a boat of dory build, 16 feet over all, 5 feet beam, 4 feet wide at stern, 3 feet 4 inches at bottom amidships, 3 feet at stern. Stem post cut under to prevent heavy shocks on striking drift. The flare on the sides gives additional stability to enable men in the water to crawl into the boat over the gunwales without swamping it. It should pull two pair of oars and have seat for steering oarlock on each side at stern; an iron-lined notch should be provided in middle of stern to lead an anchor cable through, and ringbolts bow and stern by which it may be slung. The boat should be flat bottomed, with small keel under the run aft. A heavy keelson should be used in construction to give longitudinal stiffness. Such a boat should weigh probably four hundred pounds.

Suggested method of carrying out recommendations 4 and 5 is shown on sketch herewith, No. 4.* A triple block is thought necessary to avoid unduly racking the trestle. The pull is necessarily parallel to axis of bridge and with the fall used at Fort Riley (one double and one single block), it was necessary to have twelve men to pull, and the racking was excessive. A spare trestle chain would form the best sling at bottom. The upper sling, suitable for present or suggested form of trestle leg, is shown on sketch. The block and fall is also found useful in raising anchors when firmly imbedded in bottom.

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* Not printed.

I desire to particularly commend the services rendered by the following men of the company during the maneuvers:

Sergeants Loper, Hurtt, Robbins, Lunny; Corporals Regan, McGrath; First-class privates Bolduc, Doyle, Layton, Leary, Stewart; Second-class private Fletcher.

Sergeant Crotty, of Company D, made a very good sketch of the site with the improved cavalry sketching case.

Sergeant Davignon, of Company A, did noticeably good work with a boat party during the construction and dismantling of the bridge.

Very respectfully, your obedient servant,

C. A. F. FLAGLER,
Captain, Corps of Engineers,
Commanding Company C.

RIVER RECORD.

Date.	Time.	Reading.	Date.	Time.	Reading.
September 20	------------	−1 foot, 6 inches.	September 30	1.30 P. M.	+5 feet, ½ inch.
September 21	A. M.	−1 foot.		4.30 P. M.	+5 feet, ½ inch.
	P. M.	−8 inches.	October 1	8 A. M.	+4 feet, 11½ inches.
September 23	A. M.	−10 inches.		12.45 P. M.	+4 feet, 11½ inches.
	P. M.	−8 inches.	October 2	7 A. M.	+5 feet, 4 inches.
September 25	A. M.	−2 inches.		8.30 A. M.	+5 feet, 5½ inches.
	P. M.	+10 inches.		10.30 A. M.	+5 feet, 4½ inches.
September 26	A. M.	+4 feet, 10 inches.		2 P. M.	+5 feet, 4½ inches.
	2.45 P. M.	+5 feet, 3½ inches.	October 3	7 A. M.	+5 feet, 5½ inches.
	3.15 P. M.	+5 feet, 4 inches.		3.30 P. M.	+5 feet, 6½ inches.
	3.45 P. M.	+5 feet, 4 inches.	October 4	7 A. M.	+6 feet, 7½ inches.
September 27	8 A. M.	+5 feet, 9½ inches.		10 A. M.	+7 feet, 6 inches.
	10.15 A. M.	+5 feet, 8½ inches.		3 P. M.	+7 feet, 9 inches.
	4.45 P. M.	+5 feet, 3 inches,	October 5	3 P. M.	+6 feet, 3 inches.
September 28	8.45 A. M.	+4 feet, 7½ inches.	October 6	9 A. M.	+5 feet.
September 29	9 A. M.	+4 feet, 8 inches.		3 P. M.	+4 feet, 4 inches.
	10 A. M.	+4 feet, 8 inches.	October 7	9 A. M.	+4 feet.
September 30	8.30 A. M.	+5 feet.	October 8	7.50 A. M.	+4 feet.
	11 A. M.	+5 feet.	October 9	8.30 A. M.	+3 feet, 8 inches.

Note.—From September 20 to 25, inclusive, and from October 5 to 9, inclusive, readings were measured **from mark set at each reading**, and were rather inaccurate. From September 26 to October 4, inclusive, readings **were made from a** graduated gauge established at the bridge site. This gauge was destroyed by a shore **cable on October 4** and was not replaced.

VELOCITY.

September 21. One current measurement, very rough, at lower ford **center of channel,** gave 3½ feet per second.

September 26. At bridge site, mean of three measurements near north **shore gave 4.35** feet per second. Mean of two measurements near center **of channel gave** 3.7 feet per second.

October 7. At bridge site, fifth boat from south shore (two measurements) 3.71 feet per second.

Eighth boat from south shore (five measurements) 3.73 feet per second.

Fourteenth boat from south shore (five measurements) 3.6 feet per second.

Fifth trestle from north shore (two measurements) 3.28 feet per second.

ORDERS FOR BRIDGE GUARD.

The guard will consist of one non-commissioned officer and twelve privates. The guard will be mounted daily at 6 P. M.

From 6 P. M., until 6 A. M., one private will be on duty on the bridge at all times. It shall be his duty to see that no one comes upon the bridge (except members of the guard) without proper authority, and to guard the bridge from drift or other danger.

From 6 A. M., until 6 P. M., two privates will be continually on duty, No. 1 at north end of bridge, No. 2 at south end of bridge. They will be equipped with carbine, belt, and six rounds of ball cartridge.

The orders for Nos. 1 and 2 from 6 A. M., to 6 P. M., are as follows:

To notify civilians who desire to cross the bridge that they do so at their own risk, and to prevent their loitering upon the bridge.

To direct all foot troops crossing the bridge to march in columns of twos at broken step.

To direct all mounted troops to dismount and cross the bridge in column of twos, horses outside and men leading in middle of bridge.

To direct artillery or wagon trains to cross with an interval of one bay between teams.

To require pack animals to be led as prescribed for mounted troops.

No loose horses or cattle will be allowed on the bridge at any time.

Enlisted men not on duty will not be allowed to loiter on the bridge.

Officers will be permitted to cross mounted if they so desire.

Care will be taken to see that no team, horse, or body of troops be permitted to come upon the bridge for crossing while another such is crossing in the opposite direction.

Guards will render the customary salutes of sentinels.

Guards will, at all times, make every effort to protect the bridge from drift or other danger, and will turn out the entire guard if the danger be great.

The guard will visit camp for its meals, leaving two men in the guard tent in addition to the sentinels on post.

Guards will halt troops crossing the bridge if violent oscillations are observed, until the oscillations cease.

During passage of the bridge by any troops one man (in addition to sentinels on post) will be in the guard skiff below bridge ready to go to the assistance of any one who may fall off the bridge.

One member of the guard will at all times be kept within hearing of the telephone in the guard tent.

The diagonal bracing of the trestles will be slackened whenever rain begins to fall and tightened again when the bracing is dry.

(Signed) C. A. F. FLAGLER,
Captain, Corps of Engineers, U. S. Army,
Commanding Company C.

COMPANY D, 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS,
NOVEMBER 17, 1902.

THE ADJUTANT,
1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS.

SIR: I have the honor to submit the following report of the work done by Company D, 1st Battalion of Engineers, at the Fort Riley maneuvers, and recommendations in reference to equipment.

The work of the company naturally comes under two heads, work done acting as infantry and work as engineers.

As the work as infantry has no bearing upon the subject of equipment it may be briefly dismissed by stating that the company, acting as infantry, took part in the following exercises: September 24, as part of outpost for an army corps; September 27, as part of advance guard for a division; September 29, contact problem for all arms; October 6, after 10 A. M., as part of line for defense of intrenched position; October 7, as part of tactical exercise for a division.

The engineer work of the company comprised foot and mounted reconnoissance and drafting; construction of 40-foot trestle bridge across Three Mile Creek with material of bridge train, using a Birago trestle for the middle support; cutting approaches to fords on Three Mile Creek, and south approach to ponton bridge across the Kaw River; construction of typical sections of various forms of intrenchments, viz, skirmish trench, kneeling trench, standing trench, complete trench, shrapnel trench, and shell trench, and also of gabion, hurdle, sandbag and sod revetments, for illustration of lecture on intrenchments; tracing and supervising construction of intrenchments on the right of the defensive position occupied by the Blue forces under command of Major Leach, October 6, and constructing that part of intrenchments occupied by Company D. (A special report of the work done on this day has been heretofore submitted.) In addition, details from the company were furnished Captain Flagler from time to time to assist Company C in constructing the ponton bridge across the Kaw River.

The engineer equipment of the company was transported to Fort Riley by one escort wagon and three pack mules and was composed as follows: For reconnoissance, 6 cavalry sketching cases, with necessary paper, pencils, erasers, etc.; for field fortification, 30 shovels, 12 picks, 1,000 sandbags, 3 gabion forms, 1,500 feet of tracing tape, 12 machetes, and 6 gabion knives, and for general use in road and bridge building and all other classes of engineering work, a miscellaneous assortment of tools.

With reference to this equipment the following suggestions and recommendations are submitted. For reconnoissance, the cavalry sketching case gave excellent results, but it is believed that this was due not only to the careful work of the observers and of the topographical officer but also to the excellent check afforded by the section lines, and that for general work a better and more accurate instrument can be devised. The equipment of each company should include for reconnoissance work, 6 sketching cases, 6 wrist watches, and the necessary instruments and supplies to complete field maps and reproduce them by blue printing. These instruments should include one small drawing board or table, one small blue-print frame, one set of drawing instruments, one triangular scale, one ruler, and one triangle.

The instruments and supplies for the larger and more elaborate map reproductions should be available at the engineer depot when required, but should not ordinarily form a part of the company equipment.

As this subject has been reported upon by the Battalion Adjutant, I will merely state that the necessary instruments for making the ordinary topographical signs would have expedited the work greatly and should be included at least in the depot outfit.

For field fortification, the tools carried in the tool wagon as part of the equipment should be limited to those necessary for use of the foot sections only, and should include about 250 sandbags 60 shovels (short handles), 30 picks, 12 bill hooks or machetes, and 3,000 feet of tracing tape in 150 foot lengths, each, marked every five feet and attached at one end to picket upon which it is wound. For general pioneer engineering work the tools should include 24 axes, 6 adzes, 4 cross-cut saws, 6 sledges, 12 iron wedges, 1 grindstone, 12 long-handled shovels, 6 mattocks, 3 cant hooks, 12 canvas buckets, 100 pounds assorted nails, 2 sets blocks and falls, 6 crowbars, and 1 special set of carpenter tools in which the ordinary tools should be increased by 12 cutting pliers, 12 hand saws, 12 ship augers, one-half or five-eighths of an inch, depending size of drift-bolts and bolts carried, 6 wood augers, two inch; 12 chisels, two inch; 6 carpenter mallets, 12 steel squares, 1 cutter, to make dowel pins for two-inch holes; 12 two-foot rules, 12 hatchets, 6 hand axes, 4 tapes, fifty or one hundred feet; extra files, saw sets, and oil stone to keep these extra tools in order. A special tool chest or chests should be constructed for the transportation of these carpenter tools as the ones used at Riley are entirely unsuitable. What is needed is a chest with strongly-built trays so designated as to give ready access to the tools, yet hold them securely in place when packed for transportation.

In addition to these tools a small horseshoer's kit, and fitted shoes for all the draft mules should be provided.

The remainder of the load of the tool wagon up to the allowable limit of weight should be made up of drift bolts, bolts, nails, rope, and marlin. A special tool wagon should be provided, properly designed for convenience of loading and ease of access to tools, for the escort wagon is not suitable for the purpose. If, however, the escort wagon must be used for the present, I strongly recommend that a standard loading be developed by actual test, so that the unsatisfactory state of affairs experienced in handling these loads during the Riley maneuvers may be remedied as far as possible. It is to be remarked that the standard load and standard loading are both dependent upon the form of wagon used, and it is probable that the list of tools suggested will require modification. The engineer epuipment of the mounted section was carried on the pack mules and for two of these mules a standard load was adopted, which will need minor modifications, if any.

The loading for the other two mules intended for engineer material should be determined. In my opinion one of them should carry all the tools and supplies for demolitions; and the other, rough carpenter tools, folding cross-cut saw, nails and other supplies for bridge repair work. The efficiency of the mounted sections of the battalion could be increased and their administration simplified by the appointment of an assistant veterinarian with the rank and pay of sergeant, to perform the duties of stable sergeant and look after the health of all the animals, and the appointment of a farrier and horseshoer for each section, to have the rank and pay of corporal. It is also thought that the enlistment of special men as teamsters for the bridge train with necessary increased compensation, say

$25 per month, to make their pay equal to that of similar quartermaster employees, would add materially to the efficiency of the battalion.

Very respectfully,

J. B. CAVANAUGH,
Captain, Corps of Engineers,
Commanding Company D.

APPENDIX NO. 8.

HDQRS. 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANSAS,
NOVEMBER 4, 1902.

MAJOR SMITH S. LEACH,
CORPS OF ENGINEERS,
FORT LEAVENWORTH, KANSAS.

SIR: I have the honor to report on the photographic and map reproducing departments of the 1st Battalion of Engineers, as follows:

PHOTOGRAPHIC OUTFIT.

1. There was carried to Fort Riley a complete outfit for making 5 by 7 to 10 by 12 photos. This outfit had been furnished by the Engineer Department, and although in store at this post for several months it had not been tested or thoroughly examined. This, of course, was due to the fact that this battalion had barely sufficient storage room for this property in its original package, there being no place available where it could be opened and examined. For this reason a number of defects were found after the setting up of the apparatus at Fort Riley.

2. *Cameras.*—The large camera is a 10 by 12 portrait camera mounted on a transit tripod, wholly unsuited for outdoor work, as the mounting of the camera makes it unwieldy. In a light wind there is so much vibration that photographs can not be made. The shutter is too slow for any moving object. The lens, however, is excellent.

The small camera, a 5 by 7 Premo, Sr., is a good camera for outdoor work but the shutter was found to be broken, and considerably over seventy-five per cent of the plates exposed were destroyed. This shutter has been sent off for repair.

A copying camera should be provided for copying maps and sketches. It should be sufficiently long to permit copies of same size as original. There should be provided also a stand for the copying camera. This should be collapsible, and so arranged that it will pack into a convenient shaped package.

3. *Plates.*—The packages of plates were in good condition except where tacks had been driven through the cover into the edges of some of the plates, each tack breaking one or two plates. This was due to carelessness in fastening the address card on with tacks long enough to go entirely through the wood of the cover and into the plates. It is suggested that great care be taken in driving nails or tacks into boxes containing plates. When plates are to be kept some time, or when it is probable that the boxes will get wet, the plates should be sealed in tin.

4. *Paper.*—The paper was in good shape, packed in tin. The tropical solio seems to be the best paper for use in the field, but some velox and bromide paper should be carried. In packing, it would be better to pack each gross in a separate tin box. Tin boxes should be marked with contents.

5. *Chemicals.*—Several important chemicals, although in stock, were not carried. A complete assortment should be carried for any possible contingency. All salts should be packed in bottles or tin cans.

6. *Apothecaries' scales.*—The scales carried were small balances, weighing only up to one-quarter of an ounce, apothecaries. Those provided for the photograph outfit should weigh up to two pounds, avoirdupois.

7. *Dark tent.*—The tent provided was a small canvas tent with poles, allowing the passage of more white light than a new hospital tent. A portable dark tent is absolutely needed and it is believed that such a tent can be obtained, as the Signal Corps provides a good dark tent.

8. *Trays, graduates, bottles, etc.*—Glass bottles and graduates can be carried in the field if properly packed. An ample supply of agate and rubber-ware trays should be provided capable of nesting, also ample supply of bottles, graduates, funnels, etc., to replace those broken.

9. *Lights.*—The ruby lantern is of good quality. It is thought, however, that an acetylene burner will be more useful in the field than an oil burner, assuming, of course, that an ample supply of the carbide is carried. An ordinary white light, burning acetylene or oil, should also be provided.

10. *Work tables, etc.*—None were provided, but the photographic outfit should include two 6 by 2 foot collapsible work tables, so arranged that they can be packed into conveniently shaped packages.

11. *Packing cases.*—All photographic apparatus and materials should be packed in cases or crates. These cases and crates should have hinged sides and staples and padlocks; should be strong and as light as is consistent with proper strength; should be of as nearly uniform size and shape as possible to permit close packing. Each case or crate should have countersunk handles and should be conspicuously marked "1st Bat-

talion of Engineers," "photograph," and in smaller letters on the lid there should be marked the contents. A castle surmounted by a "1" should also be stamped on each case and crate.

The following cases and crates should be provided:

One camera case for each camera and its plate holders and lens.

One canvas case with straps for each tripod.

Two cases for bottles of chemicals, with interior frames to hold bottles firmly in place.

One case of chemicals in bulk.

One case for hyposulphite soda.

One case for graduates, funnels, and a nest of trays, and a compartment for apothecaries' scales.

One case for plates and paper.

One case for sundries (as scissors, knives, clips, trimming glass, drying racks, hammer, tacks, screw driver, screws, twine, matches, etc.)

One case for dark tent.

One case for hospital tent.

One crate for (print washing) can and rubber buckets.

One case for lamps.

One crate for folding camp stools (with four stools.)

12. *Tent.*—A hospital tent should be provided as part of the photographic outfit, and it should not be counted as part of the battalion tentage.

13. *Spring wagon.*—It is believed that the photo outfit can be carried in a spring wagon, but in any event a spring wagon would be of great assistance in carrying around the photographer with his camera, plates, etc. At Fort Riley it was impossible to obtain all the views desirable for lack of such a wagon.

14. *Sundries.*—Before taking the field with the photographic outfit a careful list should be made of all sundries that may be needed, and these should be liberally provided.

MAP REPRODUCTION.

15. *Drawing boards.*—Four of the folding drawing board stands were carried and found to be very convenient. No change is suggested.

16. *Drawing instruments.*—One large set of drawing instruments and small set were carried. The instruments in these boxes were insufficient for the four or more draftsmen who were nearly continuously at work. There were lacking also road pens, proportional dividers, etc., and map measurers. It is recommended that four drawing sets be carried, each set to contain one large right line pen, one small right line pen, one

dividers, large; one bowspring dividers, one compass with lengthening bar and pen and pencil points, one bowspring pen, one bowspring pencil, one road pen, one proportional dividers, one railroad pen, one contour pen, one crowquill penholder with pens, one semicircular G. S. protractor, four celluloid triangles (one large 45 degree, one small 45 degree, one large 30 degree, one small 30 degree); one set celluloid irregular curves, one steel straight edge, one celluloid straight edge, one wooden straight edge, one T square, two boxwood scales, one map measurer, two dozen thumbtacks, two bottles of black ink, and one red and one blue, two penholders, four dozen assorted pens, two steel ink erasers, two rubber ink erasers, two rubber pencil erasers, one dozen assorted pencils, one small wooden pantograph. These articles to be neatly packed in a suitable case.

It is recommended also that a fifth case of instruments be provided, to contain a small wooden pantograph, one full circle swing-arm protractor, reading minutes, one beam compass complete, three steel triangles, two steel straight edges, four celluloid straight edges, four wooden straight edges, one gross of thumbtacks, one gross of pencils, assorted; one dozen of penholders, two boxes of pens, six crowquill penholders, one box of crowquill pens, two dozen bottles of black ink, one dozen bottles of ink, assorted colors; the lettering device and device for topographic symbols. (See par. 32.) To be packed as above.

17. *Blue print frame.*—The large blue print frame was found to be very useful, but it is thought that a smaller frame should also be carried on account of the greater ease in handling a small frame. The large frame, however, should always be carried. Instead of the loose cotton backing, a stiff felt pad should be provided. There should be carried a stand for the blue print frame. It is possible that a combined packing case and stand can be made. If not, each will have to be provided.

18. *Washing trays.*—One large zinc tray and one medium size japanned tray were carried. They could hardly be improved on. At least two of the larger trays should be carried and one of the smaller.

19. *Zincographic outfit.*—A portable zincographic outfit should be provided. At present the battalion has no method of reproducing maps at night or in cloudy weather.

20. *Hectograph.*—A hectograph should be provided. This will be found useful in reproducing rough sketches.

21. *Neostyle.*—A rotary neostyle was carried, but was not used. It is thought, however, that it should be carried as part of the map reproducing outfit.

22. *Preserving tubes.*—Five or six of these tubes were carried and found to be useful. The covers are not well made and were nearly all knocked off. A better type should be provided in the future. At least six of each size (about 44 inch and 26 inch) should be carried.

23. *Drawing paper.*—Both the backed and the plain drawing paper should be carried as well as paper for the sketching cases. Paper should be in rolls of 24 inch and 42 inch paper.

24. *Tracing linen.*—Should be 24 inch and 42 inch, and should be carried in preserving tubes.

25. *Blue print paper.*—That carried was not fresh and did not make good prints. The paper should be absolutely fresh and liberally supplied. The proper sizes are 24 inch and 42 inch. Some blue print cloth should be carried (possibly as much as one-half.)

26. *Black process paper.*—Some of this paper was carried to Fort Riley and tried there. The paper was of such poor quality that it could not be handled—even in unrolling, it would tear, and it was absolutely impossible to print with it. There is no reason why a heavy paper should not be sensitized with this preparation. If a good paper can be had several rolls should be carried. Sizes, 24 inch and 42 inch.

27. *Brown process paper.*—This paper was tried at Fort Riley for both negatives and positives, but not with great success, possibly because of lack of experience in handling. It is certain that this paper will produce good results and it should therefore be carried. Rolls of 24 inch and 42 inch.

28. *Lights.*—Four good lamps should be provided, with shades, and with rochester oil or acetylene burners.

29. *Tent.*—A hospital tent should be provided as part of the equipment of this department, not to be regarded as part of the battalion tentage.

30. *Wagon.*—An escort wagon should be provided exclusively for the map reproduction outfit, and such surveying instruments as may be carried.

31. *Packing cases and crates.*—The remarks in paragraph 12 apply also to the cases and crates for the map reproduction outfit. The marking should be the same as given in paragraph 12, except that the word "photograph" must be replaced by the word "map."

The following crates and cases are needed:

Five cases for "drawing sets" (contents as given in paragraph 16); four to six cases for drawing paper, tracing linen, blue, black, and brown print papers, manila paper and blotters; four crates for drawing boards, one crate for trays, two crates for blue print frames, one crate for print washing can, one case for hectograph outfit, one case for neostyle, one case for stationery for neostyle and hectograph, one case for hectograph, cases for zincographic outfit, two cases for lamps, one case for hospital tent, one case for sundries.

32. *Lettering and topographic symbols.*—An outfit should be provided for lettering drawings and for making topographic symbols. (As used on the Mississippi River survey.)

WORK DONE BY THESE DEPARTMENTS AT FORT RILEY.

33. The battalion photographer made about thirty good negatives, but probably at least seventy-five exposures were made, the rest being failures due to defects in the cameras. Some prints were made from these plates, but none were sent out, as complete sets had not been made. Full sets will, however, be sent to the Adjutant General, the Chief of Engineers, the Division Commander and others.

34. Tracings, in eleven sheets, were made of the route sketch of the march of the battalion to Fort Riley, and three sets of blue prints were sent to the Division Commander.

A tracing was made of reconnoissance sketches (made by the battalion) of the Fort Riley reservation and adjacent country. Blue prints of this were sent to the Division Commander and the Assistant Secretary of War.

Two of the enlisted draftsmen prepared sketch for Colonel Wagner's lecture.

Very respectfully,

H. BURGESS,
1st Lieut., Corps of Engineers,
Adjutant, 1st Battalion of Engineers.

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No. 9.
OCCASIONAL PAPERS,
U.S. ENGINEER SCHOOL OF APPLICATION,
UNITED STATES ARMY.

REPORT

UPON

SURVEY OF MANEUVER GROUNDS

AT

WEST POINT, KY., AUGUST, 1903.

BY

2d LIEUT. N. E. BOWER,
CORPS OF ENGINEERS.

ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.,
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REPORT OF 2D LIEUT. N. E. BOWER, CORPS OF ENGINEERS.

FORT LEAVENWORTH, KANS.,
January 10, 1904.

BRIG.-GEN. GEORGE L. GILLESPIE,
CHIEF OF ENGINEERS, U. S. ARMY,
Washington, D. C.
(*Through Military Channels.*)

GENERAL:

In compliance with instructions contained in your letter of the 19th ultimo, I have the honor to submit the following report on that part of the work of the Engineer Detachment under my charge at West Point, Ky., pertaining to the preparation of the map for the maneuvers.

On August 3d, 1903, in obedience to orders, I reported to Col. O. H. Ernst, Corps of Engineers, Engineer Officer, Department of he Lakes, at Chicago, Ill., for instructions. Col. Ernst's written instructions defined the work which was to be done and prescribed the time before the expiration of which it must be done. He also specified the scale to which the map was to be drawn, the contour interval and other details. I was directed to report to him weekly the progress made. Mr. A. H. Grohman, C. E., junior engineer in the Chicago office was directed to report to me at West Point as draftsman.

Previous to leaving Fort Leavenworth, a general idea of the work being had, a list of the surveying and drafting instruments which would probably be required, was prepared and left with the Battalion Commander, in obedience to his instructions. A copy of this list was taken along to Chicago. Likewise a list of the enlisted men selected from the Battalion was prepared and left with the same authority in order that they might be prepared to start on their journey as soon as further word was received.

It was the wish of the Battalion Commander that as far as possible all instruments and supplies be furnished by the Engineer Officer of the Department in which the work was to be done; the remainder to be supplied by the Engineer Battalion. Such instruments as could be supplied by Col. Ernst were then deducted from the list and the Battalion Commander was at once requested to forward the remainder. The proper steps were taken to have the detachment sent on promptly. Col. Ernst furnished all the maps and information he had succeeded in collecting through correspondence with various sources. I was introduced by letter to Dr. J. V. Prewitt, of West Point, Ky., who was requested to outline the territory and give other information I might desire.

I reached West Point on the morning of August 4th. Mr. Grohman reported to me the following day from Chicago. As no instruments nor men could arrive for at least a couple of days this time was spent in going over the ground, planning the work and making arrangements for carrying it on rapidly when once the enlisted men arrived.

As a result of Col. Ernst's efforts to procure maps, little that was of practical value was gotten. The tract lay principally in Hardin County, the western portion only being in Meade County. No map of Hardin County had been made by the Geological Survey. Their map of Meade County was procured but was of little practical value owing to the small scale. Some elevation points were checked from it, however. A map of the State of Kentucky by Rand and McNally was at hand. A sketch map made by an engineer from the Illinois Central Railroad was procured and although it was very incomplete and crude (about 150 square miles having been gone over by one man in nine days) it was nevertheless of great value in planning the work. It illustrated the fact that a graphical illustration, however crude and incomplete, when made by an intelligent person gives greater satisfaction to succeeding map makers than information gleaned from farmers and other country people. A map of the right of way of the Illinois Central Railroad, which meanders through the tract from north to south, was procured.

The country embraced in the tract was found upon arrival, more difficult of survey than anticipated. Much of the land was uncleared or only partially cleared. At this season of the year the leaves were on the trees and the underbrush in the woods and along the fences formed considerable obstruction to vision and contour methods. The numerous orchards, worm fences, small fields and corn crops would materially delay progress. As the field work was to be completed in a month's time it soon became evident that much time and thought would be required to so plan the work that the desired results should be attained and all parts receive the proper degree of attention.

As soon as the instruments arrived from Chicago and before the detachment arrived, two civilians were employed to prepare triangulation stations. One, a carpenter, was paid $3 per day; his assistant getting $1.50 per day. Mr. Grohman and I then took the usual reported readings at the stations. The measurement of the base line was delayed till after the arrival of the detachment.

In compliance with the following order:

Special Orders, No. 161. FORT LEAVENWORTH, KANS.,
August 6th, 1903.

1. In accordance with telegraphic instructions from Headquarters Department of the Missouri, dated Omaha, Nebr., August 4th, 1903, the following men belonging to the 1st Battalion of Engineers will proceed to West Point, Ky.:

Sergeant Robbins, Company C, in charge of detachment; Sergeant DeGraff, Company A; Sergeant Lowenheimer, Company A; Sergeant Crotty, Company D; Sergeant Bealler, Company D; Corporal Howry, Company A; Corporal Grissom, Company A; Corporal Layton, Company C; Corporal Fluegel, Company D; Corporal Marron, Company D; Corporal Moffit, Company D; Private Baker, Company A; Private Watson, Company A; Private Pope, Company A; Private Howard, Company B; Private Crary, Company B; Private Hosch, Company B; Private Moller, Company B; Private Fletcher, Company C; Private Richardson, Company C; Private Smith, Company D; Private Hagen, Company D; Private Grim, Company D.

A mess outfit and the necessary tentage will be taken.

The Subsistence Department will issue two day's travel rations and 30 day's field rations for 23 men.

The descriptive lists of these men will be forwarded to 2d Lieut. Nathaniel E. Bower, Engineer Corps, West Point, Ky.

Upon arrival at West Point, Ky., Sergeant Robbins will report to 2d Lieut. Nathaniel E. Bower, Engineer Corps, for instructions.

The Quartermaster's Department will furnish the necessary transportation.

The travel enjoined is necessary for the public service.

* * * * * * *

By order of LIEUT.-COL. WYGANT:

JOHN H. BEACOM,
Capt., 6th Infantry, Adjutant.

the detachment arrived at West Point on the evening of August 7th. The instruments, drafting supplies and rations were brought along as baggage and excess baggage.

The following is a complete list of the instruments and supplies, and if it had been supplemented with one rake, one pick mattax, one shovel and two lamps, it would have fulfilled all requirements. The lamps were bought and the tools were borrowed at West Point. Material for six more stadia rods was purchased and they were painted in the field.

DRAFTING INSTRUMENTS, ETC.

Two field drawing boards; one steel ruler, 36-inch; two steel rulers, 24-inch; six boxwood triangular scales; five celluloid triangles, assorted sizes; one celluloid triangle, large, 14-inch; one dozen drawing pencils, H H H H H H; one dozen drawing pencils, H H H H; 10 yards drawing paper, 36-inch; 10 yards drawing paper, 36-inch, mounted; five yards drawing paper, 56-inch, mounted; five yards tracing cloth; three bottles drawing ink, black; one bottle drawing ink, red; one bottle drawing ink, blue; six lead pencil rubber erasers; three ink rubber erasers; one sponge rubber eraser; one circular protractor, 8-inch; two semi-circular protractors, 5-inch; three dozen thumb tacks; three dozen drawing pen; one dozen crow-quill pens; three crow-quill pen holders; three pen holders; one T square, 36-inch; one T square, 30-inch; one T square, 24-inch; three sets drawing instruments, in cases; one opisometer; one border pen; one steel eraser; two irregular curves; six stadia reduction charts; two paper protractors; 12 note books; one proportional dividers.

SURVEYING INSTRUMENTS, ETC.

Three engineer transits; two levels; three plane tables; four sketching cases, cavalry; two 100-foot steel tapes; two level rods; 22 marking pins; six stadia rods (afterwards increased to 12); three hand saws; six hatchets; two axes; 10 pounds 10d nails; five pounds 20d nails; two pounds shingle nails; two pairs wire pliers; two stone cutters points; six machetes.

One day was now required for arranging camp, adjusting instruments, making stadia rods, stakes, etc., and for giving the necessary preliminary instruction. Authority was gotten for the hire of one two-horse spring wagon and driver and four saddle horses and saddles. Only two were ever hired, however, for the reason that no horses could be found suitable for mounted sketching and as they were used for transportation purposes only, no more were found necessary. The horses all showed a tendency to enter fields or leave the main road and varied their gait, it depending upon the direction they were going.

RATES OF HIRE.

One two-horse spring wagon and driver, $3 per day.

Two saddle horses and saddles, at $1.50, $3 per day.

It was arranged that the driver of the spring wagon take care of his own horses and the persons from whom the saddle horses were gotten arranged with him to take care of their horses also. This plan relieved the enlisted men of extra fatigue duty and seemed very satisfactory as horses and wagon were promptly reported for duty every morning. We were fortunate in having a faithful old driver who continued with us till the work was finished. It became necessary at a later stage of the work to hire another spring wagon to make extra or special trips. The cost of these trips was $1 each. The use of a heavy farm wagon in which it was thought several parties could be hauled was found very unsatisfactory, for although the box was filled with straw the men preferred to walk rather than ride over rough roads and hold the instruments; and perhaps better progress was made walking. Wood was purchased from farmers and could be gotten delivered at camp for $2 a cord at first. Later a higher price was paid.

The first camp was located at Poplar Springs (near "C" on the map). From this as a central point it was intended to map all that part between camp and the Ohio River and as far to the east, west and south as expedient. Only one small triangulation system was used. To have extended this further than herein described would have required the erection of high towers and the measurement of difficult lines and consumed more time than allowed. A base line was laid out extending from a point near "C" to a point near Howard station—about one and one-third miles long, and measured three times. Other stations were:

Two on Fort Hill, one north of Howard station near the river, and two on Pilchers Hill. All distances were computed and elevations of stations determined and this system when plotted was put on the plane table for further development.

The transit-stadia method was used on the most difficult country, and the plane table method on that portion most favorable for its use.

A transit party consisted of one transitman, sergeant; one recorder, corporal or private; one sketcher, corporal or private; two, three or four stadiamen, depending upon the skill of the transitman and the number of men available, privates.

A plane table party consisted of one topographer, sergeant, corporal or private; one computer, corporal; two stadiamen, privates; one sketcher, corporal, when available.

The levelling party consisted of one instrument man, sergeant; one rodman, private.

The cook was left in camp and some days an assistant to the draftsman, Mr. Grohman, usually a sergeant. All other men were used in the field.

I, personally, assigned each party to its task in the morning and if possible visited it at least once each day. The parties were started off generally by seven o'clock, A. M., and they would not return until five or six o'clock, P. M., or until they had completed their tasks. Lunch could have been taken along every day but it was not often done as the men preferred to buy a meal if it was not given them as was sometimes the case. To carry lunch in a haversack seemed to them a great burden, or at least seemed to interfere materially with their work.

The method or plan of conducting the survey is described as follows:

One or two parties were taken out in the spring wagon each morning and these would work towards camp. The remaining parties would, if it could be so arranged, start near camp and work outward and these parties would then be brought in that evening in the spring wagon. This seemed satisfactory for the men worked better when transportation was furnished, if only one way, and it was not practicable to have transportation for all the parties both out and in. The spring wagon permanently attached was used during the middle of the day for hauling supplies—in one camp, water—and mail.

Work was started the first day with one level, one plane table and one transit-stadia party. The extra men were sent with the two last parties to learn the methods, all of the future transit men keeping notes. I personally instructed the plane table and level parties, and Mr. Grohman, who was soon to plot all notes, took out the transit party. If possible, natural boundaries were selected for the different tasks, otherwise roads and railroads, and sometimes the task was outlined on a prepared sheet for use on the plane table. The magnetic meridian established by one transit was used for all azimuth work. Later the true meridian was found several times by Polaris observations. Work was begun at the north end of the tract for it was here the maneuver camp was to be located and the territory was to be used continuously to the south for the maneuvers.

On the first day the following start was made. The level party was taken to the Illinois Central Railroad bridge across Salt River at West Point. The west pier of this bridge has feet marked on it and numbered from the top of the pier to low water. The top of the cap stone of the pier is 65 feet above low water, our datum plane. It was ascertained that a Geological Survey party had found the elevation of West Point to be 420 feet above sea level; but if any exact point was located, inquiry failed to reveal it. The above datum plane was therefore selected. The level party started here and using Johnson's method of keeping notes for differential levelling proceeded down the Louisville and Nashville turnpike for a distance of eight miles, leaving bench marks at every cross road, and where they were far distant, intermediate ones. On the bench mark stakes was marked the number of the stake and the elevation above the datum plane. The same data was kept in both levellers books. Both levellers kept notes. This work required no more attention, except to examine and check notes which was done every night. This task took about four days and the party was then put on other work until more levelling was wanted, when the same party was used again.

The plane table party was started at West Point and from the same bench mark as the levellers, the top of the pier. The table was oriented by the declinator, back sights not being taken, and all triangulation points used to check when visible. The usual text books method were then used. The computer immediately calculated all elevations which were noted in his book and were written at the plotted points by the topographer for sketching in contours. When all the desired shots were plotted at one station a new station was established and then the topographer sketched in whatever contours he could before moving from this place. The plane table party would check up elevations at the bench marks left by the levellers and invariably worked on a circuit. This obviated the necessity of return levelling, except where a discrepancy was found and no better way of finding the error known. The sketcher equipped with a sketching case was sent out to get details, by the topographer. For instance, the plane table party went through the main streets of West Point only. The sketcher then made a map of the town and this was incorporated that evening, when, as a rule, the work of that day was inked in, to prevent obliteration the following days. The first task assigned this party was all that territory under 100 feet elevation, bounded by the hills on the south and the Ohio River on the north. This was completed by this party in about seven days. I would personally visit the party and check up its elevations by observations on the triangulation stations whose elevations were already known. During this work quite an important discovery was made and as the same idea is applicable to transit-stadia work it seems worth mentioning. One of the stadia men should be very intelligent and should understand contouring well. He should then be given the general direction of the next move and allowed to go out and select and locate a new station while the other stadia-men are placing their rods for shots. The well located stations gave long courses and many shots, and saved many hours of time. Stakes with no marking on them were used for stations only.

From Poplar Springs, the first camp site, the Louisville and Nashville turnpike runs south through a deep defile with precipitous sides for a distance of over two and a half miles. The transit-stadia party started from a meridian laid out intersecting the aforementioned base line and proceeded south on the turnpike taking shots to the right and left. The needle was used only as a check on the azimuth and at once revealed any radical error. At the first opportunity it left the turnpike going to the right over the hill and completing the detour returned to camp on the road west of "C," hundred of shots being taken to the right and left and front and rear of main stations and of sub-stations. Stakes were left at all stations and sub-stations marked with the initial letter of the transit man and with the number of the station as established by that transit man since the beginning of the survey. A start could now be made at any station of this course by any transit party and a new course or circuit made. By connecting up all bench mark stakes found, it is seen that the transit stadia party also checked up the levellers work. The sketcher remained almost constantly with the recorder and using the sketching case sketched every shot and station, woods, buildings, etc. None of these sketches were incorporated in the map but they were compared with the plotted notes and names and details not contained in the notes were taken from them. They were especially valuable in showing at all times just what territory was covered and where new courses should be run. Occasionally the sketcher was sent out to sketch short roads, trails, etc. All transit-stadia work was done on circuits, each party closing on its own or on anothers stations. Each party was furnished two note books numbered one and two, used on alternate days, and containing the names of the transitman and recorder. Notes were kept as prescribed in Johnson's Theory and Practise of Surveying, except that both the A and B vernier readings were recorded for each station for use in setting up at the next station and to avoid adding 180 degrees. This has advantages and seems preferable.

The above described methods adopted for both classes of parties the first day were not changed during the survey. All parties checked their elevations by tying up on a turnpike bench mark and on every stake they came across. In the evening the transitman assisted by one or more of his own party reduced his distances and elevations and prepared his notes for the plotter. A stadia reduction chart was used to reduce all shots but stadia tables were used for courses. If his notes failed to check sufficiently close the transitman was sent out to verify the course either afoot or mounted. The sketchers put finishing work on their sketches in the evening and these were all retained and properly marked and numbered in a box in the drafting tent. After the fourth day the draftsman was kept busy every day. The plane table work was incorporated bodily by blacking the back of the sheet with lead and using a steel point to impress the lines on the large sheet. Principal points were picked through. The right of way map was reduced to proper scale and the railroad incorporated. The number of plane table and transit parties varied. Sometimes three plane table parties were used and one or two transit-stadia parties and vice versa.

The work was done from three camp sites, one at "C" (Poplar Springs), one at cross roads 81, near Tip Top and the third near cross roads 42. Each camp site was located in elevation by the levelling party branching from the turnpike and leaving bench marks at all cross roads till camp was reached. The east and west boundaries were determined by locating as many points on them as convenient, accurately, and our best sketcher was then sent along them and his stream and river sketches were then fitted on. On the west boundary this sketcher waded the creek much of the way as the banks were precipitous wooded bluffs. On the east boundary he was compelled to walk between the high and low water lines on a steep bank on account of woods.

The northwest corner of the tract is shut off from the east by a precipitous wooded cliff 400 feet in elevation. It did not seem advisable to take a transit or plane table any great distance along the railroad, the only pass way as the road way is very steep and impracticable for instruments unless plenty of time is given. It was approached from the south as far as time would admit, with accurate instruments, and then the sketching case was used to complete this corner. Hachures are shown in that portion not penetrated by instruments other than the sketching case.

The field work was completed September 3d. Approximately 48 square miles had been covered. Twenty-one full days of work were consumed, only one day being stormy. A day was lost each time in moving camp. Mr. Grohman left for Chicago shortly after, where the printing and details were added to the map, and Col. Ernst attended to the matter of photo-lithographing. Prints were received at West Point, September 16th, 1903.

An arrangement of camp was adopted and continued throughout. We had 11 tents and two hospital tents. One hospital tent was used as a drafting tent and was located at the head of the detachment street. An instrument tent was pitched at the corner of the drafting tent and one corporal assigned to the care of the instruments slept in it. An acting first sergeant was appointed and a sergeant in charge of the mess. No effort was made to compel the enlisted men to use boiled water, but the cook was directed to have it on hand for those that wanted it. One case of typhoid occurred just at the completion of the survey. Spring water was used almost exclusively. Sinks (two) were dug at every camp.

It was requested of the Department Commander that commutation of rations be given. But this could not be done and 30 days rations and a Varney camp cooker were furnished instead. I now believe that this was the better plan. It kept the men together and near camp. Although farm houses were frequent it would have required considerable additional travel to go to them for meals.

The prescribed allowance of fuel is entirely inadequate for a detachment of this size using the Varney camp cooker. To overcome the difficulty in a measure drift wood was collected when convenient to camp.

Whatever credit has been given me for this work should be shared generously with Mr. Grohman and the enlisted men. The amount of country covered in so short a time in a warmer climate than any of us were used to, during the hottest month of the year called for unusual effort. Every enlisted man did his best. Their conduct was excellent. All the work was done on private property and the orchards abounded in fruits, yet not one complaint came to me.

COMMENTS ON THE MAP, ETC.

1. A scale of yards should have been put on the map in addition to the scale of feet.

2. Houses bearing the same name should have had some distinguishing letter or number.

3. Five, ten and twenty foot contours were used by permission, depending upon the roughness or unevenness of the ground. As all were numbered they caused no complaint.

4. The system of lettering the central thoroughfare and numbering the cross roads on its right with even numbers and those on the left with odd numbers, proved entirely satisfactory during the maneuvers.

5. Farm boundary fences were not, as directed, put in on account of lack of time to locate the boundaries.

6. The map was first plotted on a scale of six inches to the mile and reduced in photographing.

A copy of the map is appended hereto.

Very respectfully,

N. E. BOWER,
2d Lieut., Corps of Engineers.

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UNITED STATES ARMY.

REPRINTS OF ESSAYS AND LECTURES ON

COAST DEFENCE

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- DEFENCE AGAINST TORPEDO-BOAT RAIDS. Silver Medal Essay by CAPT. C. S. S. CURTEIS, R.G.A. (*Proceedings Royal Artillery Institution, April, May and June, 1903.*)
- DEFENCE AGAINST TORPEDO-BOAT RAIDS. Highly Commended Essay by COL. P. SALTMARSHE, R.A. (*Proceedings Royal Artillery Institution, July, August and September, 1903.*)
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- COAST DEFENCE FROM AN IMPERIAL STANDPOINT. Lecture by COL. E. W. COTTER, h. p., R.E. (*Journal of the Royal United Service Institution, May, 1904.*)

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[Reprinted from the Proceedings of the Royal Artillery Institution, April, May and June, 1903.]

Assuming the probability of raids by a Foreign Naval Power what are the best preparations to repel them so far as the construction, armament, and organisation of our Coast Defences are concerned?

BY

CAPTAIN C. G. VEREKER, R. A.

"*In Omnia Paratus.*"

"DUNCAN" GOLD MEDAL ESSAY, 1903.

GENERAL OBSERVATIONS.

Object of Coast Defences.

Before we can discuss the construction, armament, and organisation of Coast Defences, it is necessary to consider what is the object of the defences and what are the most probable kinds of raid to which they are exposed, and from these considerations we can obtain some guide as to the best form of defence to be employed in each case.

The necessity for fortifying certain strategic points, and for protecting dockyards, has long been recognised, but the importance of this means of defence has been greatly enhanced since the introduction of steam for propelling ships, and especially during the past few years by the great increase in the speed of ships, which will enable them to reach and attack places, and to get away again, before the defending ships can obtain information of their intention or come to the rescue of the place attacked.

In our Empire the necessity for adequate defence increases daily. Other nations, who a few years ago possessed no Navy to speak of, have been building ships and increasing their Naval Estimates year by year, and the time may not be far distant when we shall no longer be able to maintain the numerical superiority over any combination of probable enemies, which we have had since the days of Trafalgar;

we must begin to realise that we may get the worst of it, at all events temporarily, and must be prepared accordingly.

There are nevertheless a great number of people in this country who do not recognise the importance of, or even the necessity for, coast defences, and who go so far as to say that we could very well do without defences at all, that the Navy could prefectly well protect itself, and that the money spent on fortifications would be much better expended on building more ships.

The true importance of fortification will probably never be really appreciated by the mass of our population until we are engaged in a maritime war.

We, who are so dependent upon our Navy and our commerce, should of all nations be the one most ready to spend money liberally, on so strengthening our arsenals and protecting our coaling stations and harbours, that in time of war they may be proof against any possible attack.

The past few years shows a very great improvement in this respect; the majority of our defences have been rebuilt and rearmed with the latest and most powerful ordnance, new harbours have been fortified for the protection of our commerce, and when all the works now in hand are completed, we should, given good training and organisation, be able to hold our own.

Only a few years ago this was far from being the case; many of our coast forts were of an obsolete type and armed with obsolete guns, and would have been perfect death traps had they had to engage ships. Our guns could in some cases not range further than 5,000 yards, while the ships at that time had guns ranging to 10,000 or 12,000 yards, and could have bombarded us with impunity.

This state of affairs must never be allowed to come about again, but, in order to prevent its recurrence, we must keep pace with the times, and as armour and ordnance improves on ships, the coast defences must be rearmed and strengthened.

The chief object of coast defences may be said to be the protection of our dockyards, which should be absolutely safe against attack in order that ships building and stores may not be destroyed and that our fleets may mobilise, rest, or refit, prior to or after an action, without the necessity of having to protect themselves.

Perhaps equally important is the protection of stores, especially coal, at our various outlying coaling stations, as without coal a modern fleet is impotent and the destruction of our reserves might place our cruisers, or fleets, with depleted bunkers, at the mercy of an enemy's ships.

A further important part played by coast defences is the assistance afforded in the protection of commerce.

In the old days of sailing ships it was customary to form convoys, which, under the protection of a few frigates, were enabled to move from port to port with a fair amount of safety. But nowadays it is pretty well recognised that this system could not be carried out; the pace of the whole convoy would be determined by that of the slowest ships, its whereabouts would soon be discovered, and its attack and destrutcion by the enemy would be very probable as we could not spare a sufficient force of cruisers for its efficient protection.

We may take it that it will be necessary for commercial vessels to look after themselves, and that the cruisers will be employed in patrolling the trade routes and in tracing or engaging any of the enemy's whose whereabouts become known.

Given trading steamers of fair speed, it should not be difficult for them to keep out of reach of an enemy's ship during the daylight, and if chased, to give it the slip during dark, and our protected harbours and coaling stations all over the world will give them opportunities of running in for protection or overhaul as required.

They will run their greatest danger when nearing these islands, especially if passing through the channel at night, as they are then most exposed to attacks by an enemy's torpedo-boats. Some naval authorities consider that no vessel should be within 200 miles of an enemy's torpedo-boat station between sunset and sunrise.

It is chiefly with a view to enabling ships to steam from port to port during the daytime, and to shelter during the night, that "harbours of refuge" have been created at suitable distances apart along our coasts.

Form of raid to which ports are liable.

The class of attack to which each place is most exposed must vary according to its geographical position, its proximity to an enemy's ports or torpedo-boat stations, and the probability of an enemy being in temporary command of distant seas.

In the heading of this essay, we assume the probabitily of raids by a foreign naval power. Raid is, however, a somewhat general term and may be applied equally well to an attack by a few torpedo-boats or to a determined attempt at destruction by a fleet of battle-ships assisted by a strong land force. It is necessary therefore to enquire into the class of raid which is most likely to be employed by an enemy before we can discuss the best means of meeting it.

Fortresses at home.

Let us first take the case of our home fortresses. The most important of these are situated on or near the English Channel, and are paricularly open to an attack by torpedo-boats in the case of a war with our neighbours over the water.

The distance from the nearest French torpedo-boat stations to Portsmouth is only about 80 miles, to Plymouth 110 miles, and to the Medway 70 miles. It is evident that a flotilla leaving their station after dark would be within easy striking distance of any of these points, and would have time to attack and get back to their station again before daylight, at all events during the winter months.

Most people agree that torpedo-boat attacks are likely to take place during the earliest stages of a war, and even in some cases before war is officially declared. At this period it is probable that the reserve ships would be mobilising and squadrons collecting and preparing for sea, and the moral result of a successful raid would be very great. An energetic enemy would spare no trouble in carriyng it out and would not hesitate to sacrifice a few torpedo-boats when even one getting the defenses through might do incalculable harm to us.

The torpedo-boats might be assisted by one or two larger vessels, either sent in to attempt to clear a passage for them through any obstacles placed in the channel, or employing gun fire in an attempt to extinguish the electric lights or take the defending batteries in flank. Small parties might also be landed for the destruction of lights or to assist in keeping down the fire of the Q.F. guns.

Any raid of a more formidable nature than this, or any deliberate attack by battle-ships, is unlikely, for so long as we have a fleet in existence an enemy would not risk damaging his ships in an attack of fortifications, and even if we should lose command of home waters, it is scarcely conceivable that he would attack when he would be at liberty to blockade our ports, destroy our commerce and cut off our food supply with impunity.

From this it may be argued that there is therefore no need for an outlay of money on extensive fortifications which will probably never be attacked, and that it would be better expended on building more ships, which might ensure our keeping command of the sea; but those who take this view sometimes forget that our dockyards are only safe from attack so long as they are known to be well armed and defended, and that were this not so, an enemy who would hesitate to attack formidable works would very likely raid and destroy weak batteries and the ships they ought to be protecting, should he succeed in eluding our fleet, even for a short while.

We may then say that, though defence against torpedo-boats is imperative, the effect of the further fortification of our dockyards is likely to be more moral than material. It is none the less important that they should be made absolutely impregnable in order that we may be prepared for any unforeseen contingencies.

From the foregoing remarks, we can conclude that our home fortresses are unlikely to be exposed to any form of raid except that by torpedo-boats.

Fortresses and coaling stations abroad.

The case is however very diffferent at fortresses and coaling stations abroad. Not only are they liable to torpedo-boat raids if within reach of an enemy's port, but they are also open to much more determined attacks both from the sea and from the land side.

Our Navy is necessarily so scattered all over the world that we can not be certain that at some time or other we may not be in a minority in some quarter of the globe; our fleet may have to withdraw or may be beaten by superior forces, and for the time being, possibly some weeks or months, an enemy may be in undisputed temporary command of that part of the sea.

It is scarcely likely that such an opportunity would be missed of capturing or destroying our coal and stores, and a raiding attack would be organised, which might be of considerable strength and would tax the garrison to its utmost to defeat or keep off until relieved.

The *permanent* capture and occupation of a place would scarcely be undertaken, so long as there was any probability of a relieving fleet from home being sent out.

Harbours of refuge at home.

Our harbours of refuge at home are also liable to raids by an enemy whose object is the destruction of our commerce.

In time of war they will be full of shipping, especially at night, and it is important that these should feel confidence in the defences protecting them.

It is unlikely that an enemy's battle-ships would be employed in attacking such ports, and they are also, for the most part, out of reach of a first-class torpedo-boat raid; but it is more than probable that an enemy's cruisers would attempt to get at and destroy the shipping, or would send in their own second-class boats or pinnaces to run the gauntlet and do what mischief they could by night.

The different classes of coast defences and the form of raid to which each is most liable can be summarised as follows:—

CLASS OF DEFENCES.	MOST PROBABLE FORM OF RAID.
A. Fortresses at home	By torpedo-boats.
B. Fortresses and coaling stations abroad	By torpedo-boats (if within reach of an enemy's port). By strong force, if command of sea temporarily lost.
C. Harbours of refuge at home	By cruisers, or by torpedo-boats and pinnaces carried by cruisers.

As each port should be so armed and organised as to be best prepared to meet the most probable attack, it will be convenient to discuss each separately and in the above order.

A. FORTRESSES AT HOME.

Defence against torpedo-boat raids.

In order to divorce our thoughts from preconceived notions and existing works, it will be well, for the sake of discussion, to take an ideal case of a harbour with a narrow entrance to be defended against this class of attack, and to examine the various means of defence which might be available and the most suitable organisation. We may then be better able to see in what way existing works and schemes of defence might be improved.

Booms.

A boom or obstruction of some kind across the channel is essential if we are to be at all sure of preventing torpedo-boats getting through.

No matter how good the gun defence and the lighting arrangements, if the boats only attack in sufficient numbers some are certain to get past, and if unimpeded, could run clear into the harbour.

It scarcely comes into the subject of this essay to discuss the various forms of booms, but the ones now in use should, we should think, be quite good enough to achieve their purpose of at all events impeding or delaying torpedo-boats.

The position of the boom necessarily affects the position of the guns and lights, and though it would usually be placed at the narrowest part of the entrance, other considerations might make it necessary to put it elsewhere and to employ a longer boom, or narrow the channel by breakwaters or the erection of "dolphins," permanently closing part of the shallower waters.

The laying of the boom is now in the hands of the Navy.

The advantages of this arrangement are not very apparent. Every available sailor will probably be required on mobilisation, and dockyard hands will have quite enough to keep them busy without having to do this work, especially when we remember that a number of men will have to remain on the spot to open the boom to let friendly vessels through, and to carry out any necessary repairs.

It would be far better to have the whole operation of protecting a harbour placed in the hands of one authority, and the R.E. could do the laying out of the boom quite as efficiently as the Navy and would work under the orders of the Military Commander of the defences. Either the Submarine Miners could do this as part of their work, or the pontoon troops could be employed, as during naval operations it is to be presumed that they would have little work to do in the field in this country.

Mines.

Mines are not as a rule employed in defence against torpedo-boats, they have other and more important work to do in acting as a deterrent to the attack of larger ships, and should not be fired on the chance of sinking such a small and fast moving target as a torpedo-boat, thus leaving a blank in the mine field. But there is one contingency which we must keep in view and which may make the employment of mines in narrow waters very necessary in the near future, and that is the possibility of being attacked by submarine torpedo-boats. Such an attack could not be repelled by gun fire, a boom, unless specially constructed, would be of little use in preventing their entering a harbour, and mines may prove to be the best weapon of defence against them.

Electric lights.

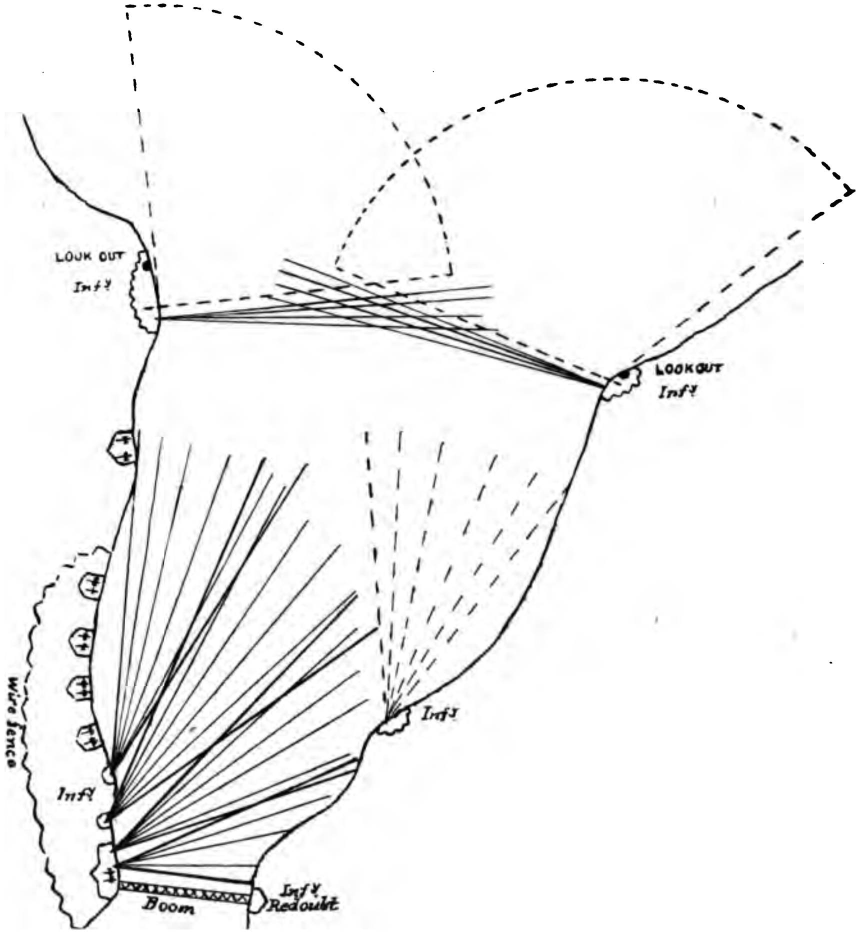
The arrangement of the electric lights is one of the most important factors in a successful defence and one of the most difficult to decide upon. The present recoginsed method is to have an illuminated area in front of the boom, and advanced lights termed "sentry beams" and "search-lights" through which boats must pass before they can reach the narrower waters near the boom. All things considered, this appears the best arrangement, as timely warning of the approach of boats can be given, and they come under close range fire as soon as they enter the illuminated area.

The scheme so often adopted of having lights and guns on both sides of the channel, is, however, not always satisfactory, though sometimes necessary owing to the breadth of the entrance.

In the ideal case under consideraion, it would be better to keep all the lights as far as possible on one side, thus giving a complete belt of light in front of the boom without any of the beams crossing each other. The most advanced of these beams should be able to light up the water close to the shore to prevent any chance of "creeping," and if it were found that the lights would not illuminate the far shore sufficiently clearly, a beam might be placed as shown by

TYPICAL DEFENCE

AGAINST TORPEDO BOAT RAID.



dotted lines in the accompaning sketch, to light up that side of the entrance.

The beam nearest the boom shoud be capable of being turned upon it, to light it up in case of an attempt at destruction, but as a rule the boom should be left in darkness.

By such an arrangement of the lights, besides doing away with crossing, we make it more difficult for an approaching boat to judge where the entrance to the harbour actually lies, facilitate the protection of the lights against an attempt at destruction by small landing parties and enables the generating plant to be kept in one place.

In the case of sentry beams, however, this will not often be feasible, and we shall have to place lights on either side. As these are to enable timely warning to be given of the approach of boats, they should be placed as far out as possible. They should always be duplicated, in case of a break down, or of its being necessary to change carbons, and the spare lights used to search the water outside the sentry beams.

All electric lights should be situated sufficiently close to the water to prevent there being much "dead water." Their protection against an enemy's fire is now practically assured by the introduction of the "parabola ellipse" reflector, which enables them to be placed behind armour in which only a small aperture 3 feet high and 2½ to 8 inches wide, according to the angle of divergence, is necessary.

Guns and works.

The 12-pr. Q.F. is an excellent all round gun for this class of defence; it is sufficiently powerful to sink a boat if it hits it and has a good rate of fire.

It is however quite possible that an enemy would send in some larger or heavier vessel with the object of smashing the boom to clear the way for the torpedo-boats, and although submarine mines might succeed in stopping or sinking it, it is necessary to include in the defence, some heavier guns capable of dealing with such a case. A group of two 6″ Mark VII. guns situated well away from the boom should answer the purpose.

All the guns should be placed on one side of the entrance when possible. This would simplify the lighting arrangements as before explained, enable an effective scheme for the distribution of fire to be devised, facilitate the rapid transmission of warning or orders and the protection of the guns from a land attack, and do away with all chances of the bad moral effect which would result from shots from a battery on one side of the channel ricochetting into one on the other side, a contingency which has now to be met by "stopping" the guns, thus limiting their effective arc of fire.

Two is the greatest number of guns which can be efficiently looked after by one officer, who, besides having to direct his fire, must attend to the supply of ammunition and the replacement of casualties, &c.; all guns should therefore be arranged in groups of two, each group being perfectly self contained and independent of all others.

These groups should be at least 50 to 100 yards apart to prevent confusion of orders and the effects of "blast" and "flash" on the laying of other guns.

The guns should be placed above and in front of the lights, with the exception of one group for the close defence of the boom. The best height above water at which they should be placed must, to a great extent, depend upon the conformation and nature of the coast line. The flatter the trajectory the better should be the chance of hitting at close range, and for this reason they should be placed as close to the water as possible; but, on the other hand, it is necessary for the efficient use of auto-sights, to have a certain amount of height and we can say that about 40 feet above the sea should be their normal position, which will give accuracy with auto-sights up to about 1,600 yards.

The high siting of guns may sometimes give what is called "dead water," upon which they cannot be depressed if the banks are steep and deep water comes close to the shore. In such a case it will be necessary to have one group close to the water's edge for the special purpose of covering this "dead water" area and prevent "creeping" by torpedo-boats.

As the batteries are not intended to withstand a heavy fire, they will not require any great amount of protection, and as they will be used chiefly at night, they should be of very simple construction.

There should be no lifts from the magazines to the gun floor and steps should be avoided as much as possible. Ample recesses should be built around the emplacements to hold all the ammunition likely to be required in action. Special attention should be paid to the sleeping accommodation for the detachments, as if they do not get good rest during the day they cannot be alert and up to the strain of continuous night work. There should also be small shelters by each gun so that a few men may always be in readiness to open fire the moment the alarm is given.

All batteries should have a slight infantry parapet in rear and should be entirely surrounded by an unclimbable fence to prevent any chance of their being rushed. If commanded by high ground within about 1,800 yards which might be occupied by a landing party, they should have a parados or a high wooden palisade to screen the detachments from rifle bullets. They should also, if necessary, be made with a strong traverse on the sea flank, to protect them against enfilade fire by a ship assisting the torpedo-boats. This traverse would also, to a certain extent, prevent "blast" from interfering with other groups.

Organisation.

As a torpedo-boat raid is the one we must be best prepared to meet, and as it may take place before mobilisation has been completed, it is important that everything should be done in peace time to keep the defence ready for immediate action.

The Royal Garrison Artillerymen available at home are only sufficient to man a small proportion of the various works to be defended in time of war; we depend in great part upon Militia and Volunteers, who on the likelihood of a declaration of war would be mobilised and allotted to their various ports, in accordance with the schemes of defence drawn up in peace time. But it is highly probable that before they were collected and settled down to their work that we would be attacked, and we therefore think that the defence against torpedo-boat raid, or, as it is sometimes called, the light Q.F. defence of a fortress, should be left entirely in the hands of the R.G.A. who are more highly trained and actually on the spot; the peace and war establishments and manning details should be identical.

To obtain absolute efficiency, the defence against torpedo-boats should be considered quite seperately in all general schemes of defence. All the light Q.F. guns and the electric lights should be controlled by one officer, who would organize the defence in peace time, train the men in their work, and command them in war. He should have under his orders at peace manning and on war mobilisation not only the R.G.A. to work the guns and the R.E. to work the lights, but also any infantry told off for the special protection of lights and batteries and the men told off to lay and work the boom.

This officer, whom we could call the Fire Commander for torpedo-boat defence, should of course belong to the R.G.A.

Though nominally under the orders of the Fortress or Section Commander, he should be given an absolutely free hand and held personally responsible for the preparation, training and organisation of send out vessels fitted with search-lights to assist the defenders in discovering the approach of ships.

Guns.

We do not require many guns in coast batteries, but what we have should be the very best and highest velocity ones available. Modern ships are very strongly armoured and unless we can penetrate their armour we cannot effectually cripple them, although by a rapid fire at the upper structures we may make them draw off.

Quick-firing is very important, especially with the lighter guns which may have but a small and fast moving target exposed for a very short time, or may be opposed to the lighter guns of ships at close range, when speed in firing will be essential.

With the heavier guns, a rapid rate of fire may also be necessary. It is the opinion of many naval officers that if ships engage forts, they will attempt to steam in at full speed to close range and then anchor, when the larger number of lighter guns they carry, and their better armour protection, may give them an advantage over the open shore batteries, which will be overwhelmed by a superior volume of rapid fire.

It may therefore be imperative for batteries to try and stop ships before they can get to close range, and fire will have to be opened at about 10,000 yards and gradually increased in rapidity as the range shortens and accurate laying with auto-sights, with which presumably all modern guns will be fitted, becomes possible.

To enable an accurate fire to be opened at these extreme ranges the guns must have a high initial velocity.

The projectiles from the heaviest guns should be capable of penetrating the belt armour of modern vessels at, at least, 2,000 yards, and those from medium guns should be able to pierce the armour of, and destroy, the secondary armament.

The new 9·2″ and 6″ guns with which most of our defences are now being re-armed fulfil the conditions of rapidity and accuracy admirably, provided they are properly handled and looked after, but it is questionable whether it will not be necessary, in the near future, to substitute heavier guns such as the 12″ and 7·5″ to enable coast defences to be equal to engaging modern battle-ships with success.

The heavier guns, provided they can be made equally rapid loading, would, for shore batteries, appear to possess many advantages.

The 4·7″ Q.F. fills no very defined position nowadays in coast defence, it is not powerful enough to penetrate the upper structures of modern ships and is unnecessarily heavy for use against ship's tops, &c., or small vessels such as torpedo-boats, for which the 12-pr. is much better suited. The most useful employment of these would appear to be as mobile guns firing shrapnel shell for the protection of landing places and the defence of positions.

All R.M.L. guns are of course quite obsolete, and even the earlier pattern B.L. guns and those on disappearing mountings are too unwieldy and slow to be of much value in an engagement and should be replaced.

As there are great advantages in reducing the classes of guns used, as far as possible, the ideal normal armament of coast fortresses should consist of:—

Heavy Q.F.'s (9·2″ or 12″).
Medium Q.F.'s (6″ Mark VII. or 7·5″).
Light Q.F.'s (12-pr.).

(The term Q.F. for all guns is used advisedly, as though at present a quick-firing gun is generally understood to be one whose charge is contained in a metal case, the expression should be applied to all rapid loading guns on mountings which allow of the laying being carried out independently of the service of the gun).

In addition to these it might, in some cases, be advisable to provide accurate high angle fire guns of a B.L. type, when there are waters which, although not requiring defence by direct fire guns, might be occupied by ships with a view to enfilading the works or bombarding a place at long range.

Works.

The introduction of high velocity guns and high explosive shell on ships sealed the doom of the elaborate granite forts, tightly packed with muzzle loaders, which figured so prominently in our coast defences, and the tendency now is to keep to works of simple trace, made as inconspicuous as possible and armed with a few good guns.

Owing to the long range now obtainable from guns, the batteries need no longer be kept close to the water's edge, but can, if necessary, be withdrawn and placed on higher ground.

The adoption of automatic sights has made it important that guns should be mounted as much above the sea as possible, and where no high ground is available, an artificial mound is raised, or the old forts are made use of as a substructure on the top of which modern ordnance can be placed.

This must be as simple as possible and the main object kept in view must be decentralisation of responsibility and the encouragement of individual initiative.

There must be one supreme head of the defences on both the sea and land fronts, but Section Commanders and Fire Commanders should be reduced to a minimum, and Battery and Gun Group Commanders should be prepared to act upon their own responsibility without waiting for orders from higher authority, for, under modern conditions, there will be little time to spare between the sighting of an enemy and the opening of fire. All orders as to selection of targets and distribution of fire should be arranged in peace time and frequently rehearsed so that when the attack takes place each individual may understand exactly what is required of him and act without hesitation.

In any case the higher commands must gradually become of less importance as ships approach the batteries, until, when these are within effective auto-sight range, we may expect to find each gun acting independently and correcting its own fire. It is absolutely impossible for a B.C. or G.G.C. to make himself heard, or to pass orders, if three or four Q.F. guns are firing with any rapidity, and it is to be hoped that this may before long be recognised by our drill books, and that our men may be trained in the observation and correction of fire of each gun by its gun captain and layer whenever auto-sights are used. This system has already been tried at practice and found to work very well; it will however, entail a much higher standard of intelligence on the part of our N.C.O's and men, more care in the selection of gunlayers, and a thorough knowledge of the guns and mounting in use.

Every gun has its own peculiarities, and it is just as necessary for a detachment to know their gun as for a sportsman to know his, or an infantryman his rifle. As at stations abroad, the men required to work the guns are, or ought to be, always on the spot, it could be easily arranged to have a number of them told off to each gun and to get them to look upon it as their own particular weapon, much as is done on board ship; they should be responsible for keeping it clean and in working order, for mounting and dismounting it when necessary, and should always keep to it at drill and use it at practice and in action.

If this were done, we feel sure that it would bring in a principle of personal emulation which could only be productive of increased efficiency, and we would not so often hear of guns missing fire or failing to run up, and the thousand and one causes of delay and waste of time, for which, as often as not, it is difficult to find anyone responsible.*

In the same manner, the Specialists should have charge of their instruments and communications and should be capable of testing, adjusting, or repairing them.

If organised on these lines, the higher ranks would then have their duties in peace and war clearly defined.

The G.G.C. would be in charge of his group of guns and their ammunition supply, the B.C. of his battery, its instruments, communications, &c., and the F.C. of his fire command; not on paper or occasionally when manning, but always, and absolutely, so long as serving in a station.

The only true test of the organisation of defences is actual war, but much could be done if Garrison Artillery were occasionally given an opportunity of testing the efficiency of their preparations by being attacked by ships during mobilisations and manœuvres.

Anyone who has read the reports on the United States combined manœuvres last year, cannot fail to have been impressed by the consensus of opinion as to the great benefit derived from them.

It would be excellent training, not only for our coast defences, but for our Navy also, if the annual naval manœuvres occasionally took the form of evading a small defending fleet and making a raid on some distant coaling station. We would even go further, and suggest that the expense entailed would be infinitesimal in comparison to the experience gained, if a division of the 1st Army Corps was embarked in transports and convoyed by a fleet for a combined attack by sea and land on one of our larger fortresses, say Malta.

C. HARBOURS OF REFUGE.

The defence of these calls for few further remarks. Most of what has already been said under *A* and *B* applies to some extent in this case.

Although it will rarely be feasible or desirable to close the entrance with a boom, there must be a good proportion of light Q.F. guns in

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*The only objection to this arrangement would appear to be the difficulties in the way of carrying out service prize firing, but the rules for this could be amended to suit the new conditions; if not, prize firing as at present carried out should be abolished, for the moment it interferes with the efficient organisation of our defences it no longer fulfils the object for which it was introduced.—*C.G.V.*

the armament, and electric lights must be provided, in order to prevent raids by small boats during dark. The defence might be greatly assisted by a line of anchored barges or pontoons carrying quick-firing guns, if the entrance is at all broad, an illuminated area being established just in front of these, but any form of floating defence should be avoided if possible as it is likely to interfere with the freedom of fire of the land guns.

If larger vessels attack they will probably be cruisers or "commerce destroyers," and to meet these an armament of 6″ guns should, as a rule, be good enough, with perhaps a few 9·2″ guns to deal with a possible attack by armoured cruisers or battleships and keep them out of bombarding range of the shipping.

These defences are not intended to stand a determined attack, which, as already explained, is an extremely remote contingency, and there is no necessity for overdoing their armament, but the few guns provided must be the very best.

An attack by a landing party being extremely probable, as some harbours of refuge are somewhat isolated, and as a large force may not be available for their protection, the batteries, while made safe from a sudden rush by means of the usual parapet and unclimbable fence, must be further guarded by small infantry redoubts occupying any high ground within range of the rear of the batteries, and which might be occupied by the enemy with a view to keeping down the fire of the guns while the attack on the shipping in harbour is made. The landing places should also be guarded by small redoubts, which might with advantage be provided with one or two 4·7″ guns able to fire shrapnel shell at any boats attempting to land men.

No elaborate organisation or chain of command is necessary, as, if attacked, there will be little doubt about what to do and how to do it, provided definite orders and instructions have been issued beforehand.

The garrison should consist in great part of local Militia and Volunteers, who will take a personal interest in the defence of their port and homes, will know the coast and surrounding country, and can be trained in peace at the work they will carry out in war, so that on mobilisation there will be no delay, and the port will be placed in an efficient state of defence against raid before the declaration of war.

SUMMARY.

The chief points brought forward for consideration in this essay can be summarised as follows:—

The seperation of the defence against torpedo-boat raids from the general defence of fortresses.

The removal of all old type guns and the retention of only three natures, Heavy, Medium and Light Q.F's, in works.

The introduction of greater independence both of batteries and of *personnel* and the encouragement of initiative.

The recognition of the liability to attacks from the land side, and the organisation and preparation of works to meet them.

We are getting good guns and good works; what we now require is good organisation and training, especially in the lower ranks, training in peace which will fit them for the work they will have to carry out in war, and make them able to depend upon themselves in the hour of need.

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Assuming the probability of raids by a Foreign Naval Power what are the best preparations to repel them so far as the construction, armament, and organisation of our Coast Defences are concerned?

BY

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"Ut Vivas Vigila."

"DUNCAN" SILVER MEDAL ESSAY, 1903.

INTRODUCTION.

Raid by a foreign power is generally accepted as meaning an attack by small vessels of very high speed, capable of inflicting damage out of all proportion to their value, on an imperial naval base, dockyard, or harbour. These vessels would be torpedo-boats or torpedo-boat destroyers, and would as a rule be escorted by a covering squadron of fast unarmoured cruisers, whose main armament would not consist of heavier guns than the equivalent of our 6″ gun. This squadron would endeavour, immediately the attack of the torpedo vessels had been discovered, to support that attack with the greatest vigour by pushing in as close as possible and engaging the batteries of the defence.

Such an attack could hardly be contemplated in daylight, and we may assume that, except at night, it would not be attempted. For the rest, the main object of the raiding craft would be to get past the forts as quickly as possible, and effect their ultimate and only object, viz., the destruction of as much *matériel* as possible in the dockyard or harbour, regardless of risk to themselves. These are the main features of raid which must be taken into account when considering what are the means and method of defence most suitable for repelling such attacks. Countermining on the part of the enemy will not be discussed, as it does not affect the system of defence, beyond establishing the principle that mine fields must be protected by guns.

As far as possible the subject will be treated under the headings given, on broad lines which it should be possible to lay down without restricting in the least that modification which must be necessary with all systems, and more especially so with that under consideration, the efficiency of which depends so much on the correct appreciation and employment of the natural advantages peculiar to each port to be defended.

I. CONSTRUCTION.

Under this heading will be considered all questions connected with the siting of works, mine fields, electric lights, and other components parts of the defence, and the relative importance of each will be dealt with, as affecting the ultimate efficiency of the whole as a completed line of defence aganist raid.

Importance of original selection of sites.

The immense importance of the siting of the works of defence and their adjuncts is obvious, bearing in mind that, owing to the expense involved, mistakes made at this point are permanent in their results, and will as a rule last until the armament mounted becomes obsolete.

Means of defense mutually dependent on each other for effect.

To evolve a sound system of defence against raid, it must be realised how, to a greater extent than in any other case, the various means of defence are dependent for their effect upon each other; and how, to obtain the maximum effect from them, these means of defence must be so placed that their action may be concentrated at the most favorable point, and they may be worked under the most favourable conditions, for the defence.

Necessity for collaboration of those responsible for original scheme.

The elaboration of an efficient line of defence is dependent on a complete mutual understanding between those officials who are in the first instance responsible for the siting and construction of the works, armament, lights, and mine fields.

If these most important questions are not, in the case of each seperate port, considered in the first instance in their order of relative importance, but decided piece-meal without sufficient collaboration between the departments responsible and the local military authorities, the defence can never be that most suited to the natural features of the place, and all subsequent organisation and framing of schemes of defence must suffer, these being dependent entirely on the original distribution of the means provided for defence.

No doubt there is not much difficulty on this point at home stations, where all concerned are practically on the spot, but abroad the case is different. It is impossible to overrate the value of the opinion of military authorities on the spot. No amount of map and chart reading can make the opinion of individuals, sometimes thousands of miles away, equal in value to the opinion of those qualified by local knowledge to express it. There are sometimes of course questions involved which regimental and other officers at a station abroad are not aware of, but this fact cannot alter the soundness of the main principle, though it may modify it in particular cases.

It would appear that the adoption of a method, such as that which follows, would almost prevent the possibility of guns being placed where they are not required, and ensure the attainment of a defence, equal to all requirements and most suited to local conditions, at the minimum cost.

Method suggested for deciding on original scheme of defence.

The authorities having decided that it is necessary to defend a port—in this case against raid—should call upon the local military authorities to submit a scheme, without limiting them in any way, for the defence of the port.

When this has been done, the heads of the departments concerned at home could criticise to any extent, require reasons for certain dispositions, limit the armament proposed if the demands were excessive, either from a financial or tactical point of view, and in fact make what observations the thought fit in order to ascertain whether the scheme suggested was sound; at the same time adhering to the principle that local recommendations should be appproved unless some very good reason to the contrary could be given.

It is not intended to suggest that any existing control should be taken out of the hands of the heads of departments at home, but merely that, retaining that power in full, they should start at the right end by allowing any scheme for the defence of a port to be based *originally* on the opinion of those who are qualified to state, from intimate local knowledge, the number, nature and distribution of the guns required for the adequate defence of the place.

The considerations governing the selection of sites for the various means of defence may now be dealt with in detail.

Works of defence and mine fields.

Mine fields should be protected and covered by the fire of Q.F. guns, hence they are in a measure dependent on there being suitable sites available for such guns within effective range of them. Conversely the siting of the guns must to some extent be governed by the question of the best sites for the mine fields. Where these sites are coincident, the best site for the mine field being immediately opposite, and within effective range of, the best site for the guns, the line of defence can at once be decided on. Otherwise the best line obtainable, with due regard for the requirements of both, must be selected. In the absence of mine fields, the guns only need of course be considered.

The requirements to be borne in mind in selecting sites for the guns are:—

(*a*) That the water area should, if possible, be so naturally restricted by reefs, shoal water, or the opposite shore that torpedo vessels running past should be within effective range of the guns throughout their arc of fire.

(*b*) That there should be as large an arc of fire as possible.

(*c*) That the site should have a command sufficient for the accurate use of auto-sights over the restricted water area, and if possible slightly greater than that of the fixed beams.

The siting of mine fields not being an artillery question, no more need be said than that they must necessarily be under observation from the shore, except in extreme cases, and the water area must be sufficiently restricted naturally, or made so artificially, if the channel be too wide.

On this question of the siting of guns and mine fields depends the position of the line or lines of defence. Other means of defence are of secondary importance in this consideration.

Fixed beams.

The siting of the fixed beams depends on the sites selected for guns and mine fields, except in the possible case mentioned later. They may exist for both, or for guns alone. Each pair of lights should, if possible, be rather on the inner side of the batteries for which it is intended, and on a slightly lower level, as previously stated, as objects in the beam are more plainly visible from above it.

As regards the beams themselves, it cannot be too strongly urged that they should combine power with dispersion; the former is sometimes sacrificed to the latter. Rather than sacrifice power the number of lights should be increased. The lights should be sufficient in number or their power and dispersion increased sufficiently, to allow the whole channel within effective range of the guns to be fully illuminated. Otherwise the full fire effect is not obtained. This is merely a matter of calculation, and the nearer the channel, the greater the dispersion required. For instance, suppose a battery of 12-prs. with its mean line of fire at right angles to a channel 800 yards distant, and down the centre of a pair of fixed beams with the usual 60° dispersion. A vessel on entering and leaving the beam will only be 900 yards from the battery, which given light, could open fire with effect at 1,200 to 1,500 yards.

Look-out posts and sentry beams.

As far as possible on the outer side of the defences should be a look-out post, in direct communication with all Q.F. batteries, and near it powerful sentry beams which should be solely employed in searching the approaches, with a view to giving as early an alarm as possible of any attack to the defence.

After the attacking torpedo vessels had passed the look-out post, these beams would probably have to be used as an exceptional case to aid the fire of the heavy guns of the outer batteries in keeping the covering fleet at a distance.

Heavy guns in outer works.

In almost all cases such guns will be mounted, and their *rôle* would be to keep the covering fleet at a distance and prevent them supporting the attack by fire on the Q.F. defences.

Brennan torpedo.

The Brennan torpedo may be a most valuable aid, but it does not affect the general arrangement for the defence in any way.

Temporary construction.

Everything possible in the way of artificial obstructions should be made with a view to narrowing the available waterway, delaying the enemy in the illuminated areas and retarding his speed.

Effect of natural features on selection of line of defence.

Under the heading of construction must also be considered how the construction of an efficient line of defence against such attacks is effected by natural features.

Harbours and dockyards may be divided for tactical purposes into three classes:—

Harbours with long approaches.

Harbours of this sort are most easily defended. By approaches is meant some sort of limited waterway, either a channel within effective range of land, or at least a waterway commanded by, and wholly within effective range of, land on both sides. In most cases the approaches are narrow throughout the greater part of their length, and in every case some narrow part adapted to the kind of defence under consideration can be found.

In this case a line of defence would be sought for which would fulfil the conditions necessary for the combined operation of Q.F. guns and mine fields and be at the same time out of range, and out of view if possible, of the enemy's covering squadron. Ample warning would be possible owing to the distance between the line of defence and the look-out post at the outer end of the approaches.

The advantage presented by such natural features is that the system of defence against raid can be concentrated with all its energy on its legitimate work undisturbed by the fire of the enemy's ships, as the fire from the light Q.F. gun usually carried by each torpedo vessel would not be of much account used at an unknown range, amid the glare of lights and for so short a time.

Harbours with short approaches.

In this case, harbours with approaches of one mile or so are referred to, when, though the possession of approaches is an advantage, the shortness of them causes the line of defence against raid to be almost at the entrance with the heavy batteries. In such cases but little choice of sites is usually possible, and the Q.F. batteries will be liable to long range fire unless the outer batteries are powerful enough to cause the covering squadron to withdraw out of range. The latter would however probably take great risks to get in close at the moment when the enemy's raiding craft were making their attempt to rush the defences, and it is stated that the effect of a powerful search-light, directed from an enemy's ship across the fixed beams and between the Q.F. batteries and the channel, is to render any vessel in the channel absolutely invisible to the defence.

If this is so, the importance of having either the outer batteries sufficiently powerful to prevent it, or the Q.F. defence sited on the inner side of a bend in the channel, is very great. Such a manœuvre on the enemy's part could not fail, if successful, to result in complete or partial immunity for his raiding craft from both guns and mines.

Harbours with no approaches.

But few cases of this sort exist, where there is open water right up to the entrance to the harbour. In such cases, the guns of the defence are all of necessity under fire of a covering squadron. More guns are required, and in some cases the greater number of the batteries must be sited in rear of the entrance to the harbour and consequently of the line of defence against raid. Q.F. batteries would, therefore, be liable to a more or less heavy fire from the enemy's ships and must be well protected. Apart from these disadvantages, however, the concentration of the defence on one very narrow point, heavily mined, is obvious, and no attempt of an enemy to force such a passage could fail to be attended with heavy loss.

Fixed beams as affected by natural features.

The siting of fixed beams would in no case be affected by natural features, but would entirely depend on the position of batteries and mine fields, unless the assumption that an enemy's covering ships could use their search-lights with the effect described above is correct. If so, the siting of fixed beams must have in some cases a most important bearing on the question of siting batteries and mine fields, and the relative importance of these three elements of the defence in selecting the line of defence must be reversed. It would mean that, unless the shortness and straightness of the approaches prevented any other arrangement, the Q.F. batteries and mine fields should not in any case, however favourable the proposed site may otherwise be, be sited within view and effective range of an enemy's ships measured from the position which they could take up in the event of their being able to keep down the fire of the outer batteries.

Siting of look-out post and sentry beams.

What is required is a position as far seawards as possible consistent with the possession of an arc of view commanding all approaches to the channel. The outer sentry beams should be sufficiently numerous and so sited that all water, especially deep water under the land, may be completely swept by their light. In some cases it may be necessary to place one or two sentry beams in between the look-out post and the line of defence against raid, where the intervening distance would otherwise enable raiding craft to lie unseen and await a favourable opportunity for attack, after having passed the outer beams.

II. ARMAMENT.

On the question of armament, there is not much to be said. We have guns, which are very good and up-to-date and a few remarks only are necessary as to the conditions which necessitate the use of certain natures of guns, and as to the grouping of them.

Guns for defense against raid.

For defence against raid, the best guns are without a doubt the 12-pr. Q.F. of 12 cwt. and the 4·7″ Q.F. They are both very accurate and have a high rate of fire with auto-sights. The 12-pr. Q.F. is quite large enough for use against torpedo vessels, and if the guns it is proposed to mount are for use in case of raid only, then there is no need to go further than the 12-pr. Q.F.

If, however, the guns are needed for use under other conditions as well, the best gun to mount is the 4·7″ Q.F.

Grouping.

No more than two guns of either nature should be grouped together in one work, except in exceptional cases, for the following reasons:—

1. Mounted in pairs, their effective arcs of fire are greater than if three or four are mounted together.

2. A pair of guns forms the most convenient tactical unit for this kind of defence.

3. If any attempt be made in conjunction with raid to land a party and take these small works in the rear just before the rush is made, they mutually support and flank each other, and their seperation constitutes an element of safety inasmuch as the guns of the defence will not all be captured by a successful assault on one work, and the enemy must divide his attacking force.

The most obvious exceptional cases are when there is only one available site, or the case of a harbour without approaches.

Machine guns.

One Maxim gun on a parapet mounting is supplied for each pair of 12-pr. Q.F. guns, but is equally necessary for 4·7″ guns mounted for defence against raid, as all works of this sort must always be liable to attempts at temporary capture just prior to the dash of the enemy's raiding craft.

Ammunition.

The equipment seems sufficient.

III. ORGANISATION.

It is proposed to discuss under this heading all arrangements for an efficient defence, excluding actual drill, which are subsequent to the erection of the completed works of defence.

General remarks on raid.

It is laid down that raid may be expected immediately, if not before war is declared, and very probably before a state of war is known to exist. In this case, the force would consist of a flotilla of torpedo-boats or destroyers, alone, or accompanied by fast unarmoured cruisers, and the enemy's chief object being to effect a surprise, there would be no hesitation or delay on his part in striking.

Probable length of warning.

The warning given by him of his intention to raid would be just that interval of time which he would take to traverse at full speed the distance between the point at which the sentry beams picked him up and the outer edge of the first fixed beam. This would be slightly increased in the event of the impending attack being discovered by any naval picket boats patrolling outside. Later on at any period of hostilities, raid might be attempted, and would undoubtedly form part of any organised attack on a naval base by the enemy's battle fleets, in the event of our own fleets being temporarily disabled or beaten.

Only certain ports liable.

Only certain ports are considered liable to raid, dependent on their distance from a possible enemy's nearest naval base, and the radius of action of the craft he would use for raiding. Those most liable are our naval bases and dockyards on the south coast of England, and those in the Mediterranean. The former would be especially liable, and such attacks on them probably of frequent occurrence. Their distance from the bases of a possible enemy is so small that thick weather could be waited for, and used to advantage by him. The warning possible is so short, that nothing but unceasing vigilance and continual readiness on the part of those entrusted with this harassing work will ensure success for the defence.

Difficulty of distinguishing friend from foe.

The grave difficulty of distinguishing between friend and foe also exists, which must add greatly to the responsibility of officers in charge of such batteries, on whose part the least hesitation in opening fire may be fatal. We are now trying to obtain a satisfactory and workable system for ensuring such distinction, but there is no doubt that any such system should be of the simplest nature, with no complicated code of signals changing day by day.

With these few preliminary remarks on the difficulties to be surmounted, an attempt will be made to discuss existing methods, and if possible suggest improvements on them.

Look-out system.

It is obvious that the more warning that can be given of raid the better; therefore the further seawards the look-out post can be placed, consistent with the effective searching by the sentry beams of the water area over which the enemy's vessels must pass, the more probable is it that his attack, as a surprise, will fail. In some ports frequent attempts at raid are so probable that this post should be most carefully selected. In some cases it is placed near the supporting battery, the position of which is governed by the examination line. This point need not of necessity be the best available. Where it is not, a seperate look-out post should be established. It should be slightly in advance of the sentry beams, and have good command with no hidden water. The system would work immediately mobilzation was ordered.

Communications. If the look-out post were at the supporting battery the examining vessel would probably give first intimation of the boats being those of an enemy. We need not discuss here the method of signalling from the examining vessel. But if the look-out post was further seawards, the individual in charge would have to trust to his own judgement as to declaring boats hostile. The difficulty does not appear to be insurmountable, and some such system as the following is suggested. Let us take the case of the look-out post being further seawards than the supporting battery. If not, the system would not be materially altered. It is believed that an alarm bell, actuated from the look-out post, has been placed in each Q.F. battery in some fortresses. No better means of alarm could exist. As much warning as possible being necessary, it stands to reason that the alarm should be given immediately any vessels, which could possibly be the enemy's torpedo craft, are sighted, the meaning of the alarm bell being simply "Stand to the guns." It should also be put in all submarine mining test-rooms. This alarm could be followed by a seperate signal, such as a rocket or signal gun, on the craft being made out to be hostile. If this proved impossible from the look-out station, the examining vessel could be trusted to give this informatoin. A simple signal might easily be decided on, in the event of the alarm proving unnecessary.

Friendly vessels. Some mention must be made of the entrance of friendly boats at night. At present all torpedo craft unless declared friendly are to be treated as hostile. The declaration of the boats as "friendly" is the difficulty. Undoubtedly all war vessels of our own entering at night would first make the examining vessel. Any system of making a friendly vessel fly a given signal in passing the defences is bad, as it might get into the enemy's hands. In some ports he could deliberately wait outside sheltered from the sentry beams and see the signal of the day hoisted by a friendly vessel on entering. If his boats made a dash past the examining vessel and then hoisted the signal whatever alarm the examining vessel gave, any officer in charge of a battery would hesitate about opening fire on a boat entering the beam with the friendly signal flying, as he might well think she was preceding hostile vessels. It seems clear therefore that what is required is a signal ashore, and not on the boat itself. A simple code of lamp signals on the flag staff of the supporting battery could easily be arranged—any boat not signalled "friendly," to be fired on. The question of friendly boats bound outwards is different. No boats bound outwards at night could be hostile, unless an enemy's boat had passed the forts already, except in the case of a harbour with a double entrance, of which none, as far as is known, exist. It is a question therefore whether any signal in this case is needed at all, as friendly vessels would hardly pursue the enemy's boats out of the harbour across the beam, while the latter were under fire from the shore. In fact all vessels passing out could well be treated as friendly, unless an enemy's boat had passed in, when all outgoing craft would be treated as hostile until the enemy had gone out again or been destroyed.

Control of Electric lights.

By some it has been advocated that the R.G.A. should have control of the sentry beams. Our existing system is that sentry beams shall not, except under most exceptional circumstances, be used to aid artillery fire. If this system is sound—and it appears to be so, for, with sentry beams aiding artillery fire, small vessels might easily pass in unobserved altogether and raid, as a surprise, be made easy—we need not burden ourselves with the direction of these lights, for no knowledge perculiar to Gunners is required to work search-lights for look-out purposes only.

Manning and fighting of batteries.

Our present system of manning, viz., two reliefs, one on, and one off, duty, a look-out man, and the guns loaded, cannot, it is considered, well be improved upon. As regards fighting the batteries, the aim and object of any system should be to make a boat the target for a continuous rapid and well directed fire from the moment it enters the beam until the moment it leaves it.

To obtain the best results from such a system, fire directions must be vested in the gun-layers, who must be trained to observe and correct their own fire. The officer in charge should be responsible for fire discipline and control, viz., the efficient service of the guns and the distribution of fire, retaining always in his hands the power of assuming fire direction as far as deflection is concerned, though with adequate training this should not be necessary at all.

Training of personnel.

The efficient training of *personnel* is affected by many questions of organisation in time of peace, and some will be touched on which, though affecting the Regiment as a whole, yet have especial reference to the case under consideration.

Regulars.

No sounder system can be found than that the officer commanding a company, on its arrival at a station where it will be called upon to man guns for defence against raid on mobilization, be ordered to tell off and keep in constant training, the number of Q.F. detachments required for the guns in time of war. These detachments should practice from their own guns at the annual prize firing.

Employed men.

If the R.G.A. are to attain a higher standard of average efficiency, commanding officers must have their men. Attempts have been made in this direction, but the results cannot be called satisfactory. The only remedy possible under existing conditions, which allow soldiers to hold extra-regimental employments, is the absolute enforcement of the principle, which under no circumstances permits the subordination of the military efficiency of the soldier as a fighting man, to the work connected with his employment.

Militia and Volunteers.

In the case of our home defences, Militia Artillery should carry out their training from guns which they may have to man on mobilization. Every facility should be afforded them, and as regards the case in point, they should be rendered familiar with every phase of attack possible, by constant drill, practice, and night manning with electric light in conjunction with the Navy. They are up for such a short time that no expense should be spared to make them efficient, and thoroughly familiar with all service conditions. As regards Volunteer Artillery, as much training as possible should be given during the very limited time at present available.

Practice.

Much has been done of late years to improve the gunnery of the R.G.A. and the great obstacle hitherto experienced, in the lack of ammunition for practice, has to a great extent been overcome by the introduction of the aiming rifle. This is of the greatest value for practice with Q.F. guns, for which otherwise immense quantities of ammunition would be required to produce a high standard of efficiency.

The use of the aiming rifle for practice is, however, confined too much to one period of the year, that immediately preceding prize firing, and this is owing to the fact that the annual allowance is still too small. The extra money needed to enable weekly practice to be carried out is very small, and should not be allowed to stand in the way. The raising of the annual allowance from £213 per company to £300 per company would be sufficient, and the compulsory expenditure of this extra money in weekly practice would go a very long way towards the maintenance throughout the year of the high standard usually aimed at for the week or so of prize firing. Results should be regularly recorded and made a subject for report.

Officers' duties.

The officers likely to be in charge of Q.F. batteries in time of war must necessarily be juniors, as seniors will be required elsewhere. Modern Q.F. guns are liable to be temporarily put out of action by some small derangement of the machinery, not necessarily actual damage. Officers in charge should be able to at once set anything of this sort to rights, and should be trained to do it in time of peace.

The I.O.M. is a most necessary official, as are his artificers. But there is usually only one I.O.M. in a district, and perhaps one artificer of sorts in each work, sometimes, though a good man, not gifted with great intelligence and not immortal. It does not seem to be realised that in time of war the I.O.M's time would be fully occupied by repair of damage, and that it is in the interests of the Service that the regimental officer should be qualified to attend to the working and adjustment of all fittings, and so free the former for the more important work which in emergency would fully occupy his time, and which he alone can be qualified to undertake. Yet in time of peace when anything goes wrong with the working of one of the intricate portions of the mechanism, how frequently is the officer, only too keen to try and set it right, told he must not touch that, but must send for the I.O.M. (or artificer) as the case may be. This is right if the officer is ignorant and will only make matters worse, but he should and must, be able to do it, and he can be taught. As it is, he seldom learns.

Physical qualifications.

The physique of men is not considered sufficiently when detailing them for Q.F. gun squads. Gunners should be given that work for which they are best suited physically. Q.F. gun drill requires men with a quick, active physique, not necessarily big men, but hard, wiry men of middle weight, who can move quickly and can last. Fat and clumsy men are utterly out of place, yet they are often seen on these guns. Selection of men of suitable physique has much to do with the maintenance of a high rate of fire.

Specialists.

When gunners are first called upon to defeat an enemy's attempt at raid, with the alternative, in the event of failure, of perhaps millions of pounds worth of *matériel* lost to the nation, the all important man will be the gun-layer. He will be at his gun waiting, see a torpedo vessel enter the beam perhaps at over 20 knots an hour, and have to stop that boat while it is under his fire, perhaps for one or two minutes only, if that in some cases. What conditions can be more calculated to upset a man's nerves, to in fact make him lay his gun less accurately than usual? Some men have a natural genius for gun laying, are always sure of themselves, have a marvellous control over elevating and traversing numbers, and always keep cool. We see it in the tests to which we put them in peace time, when they consistently lay a gun accurately in about half the time the average layer takes. Yet we let these men go when their time is up. We make no more effort to retain them than any ordinary man. We apparently go on the principle that we can always make such men. Yet, if we could keep them by making it worth their while to stay on in the Service, we should have men who would get the highest rate of fire possible, given good drill, and get a hit every round. The value of such men in war time is exactly the value of the damage saved to the nation, and it is not exaggerating to say that there are such men, but they are comparatively few. The free board of a torpedo vessel is only about four feet, easy enough to hit in daylight, but given a dim, uncertain light and nerve breaking conditions, anyone, who knows how any error with an auto-sight is exaggerated, will fear for the result with the average gun-layer. It will be worth our while to pay these men the wages they would earn in civilian life to induce them to stay.

Night firing.

In some places it is possible to carry out practice at night, yet it is seldom if ever done. Night manning means as a rule every man in his place, drill, testing communications, and blank rounds with a towed target, in fact everything except actual practice with visible results. The writer took part in night practice with Q.F. guns once, and at any rate realised from it the difficulties which obtained owing to altered conditions, and the necessity for constant practice at it. A substitute for a towed target was obtained by the mooring of six targets at unknown ranges, which were lit up seperately by the lights for one minute at a time for the Q.F. guns, it never being known which target would be lit up next. This gave a very good approximation to the target we would have to deal with in case of raid, and one realised from it most fully how different are the conditons, how badly men lay under the altered circumstances, and how difficult is the observation of fire. In some places, at any rate abroad, a little energy would enable such firing to be carried out regularly. In others, it would be worth the expense, especially at home, to erect a battery and search-light, for practice purposes only, on a suitable site, from which, with the precautions mentioned below, regular practice could take place. All that is required is a week's notice to the local authorities, and one or two picket boats at a safe distance, placed where outgoing or incoming vessels could be seen. A rocket from either of these boats would order "cease firing."

Protection for the eyes of gun-layers and setters.

The effect of a search-light, shone straight into a battery at short range in the eyes of gun-layers and setters, is to make them incapable of seeing anything for quite an appreciable period, and when time and accuracy are everything, nothing can conceivably be more important than some means to obviate it. Some sort of smoked glasses will do it, and also aid greatly in shielding the eyes of these men, on whom all depends, from the shower of dust raised by the discharge, which comes into the emplacement with a wind blowing into the battery.

Experiments.

More experiments as to service conditions, and possible manœuvres of an enemy, should be carried out in conjunction with the Navy. To mention only those points raised above, it could be ascertained exactly what effect a powerful search-light, directed across a fixed beam and between a battery and a target, has on the visibility of the latter. If it is found that it has the effect described, it has considerable bearing on the siting of batteries and fixed beams, for such a manœuvre on the part of an enemy being possible might mean a free passage for his raiding craft. Again try the effect of a search-light shone from near the target into a battery at short range, and it is believed that the need for some sort of smoked glasses will be proved.

Conclusion.

In this essay, those details already laid down in our drill books, &c., as essential, and generally agreed upon as such, have been avoided, or only mentioned as being necessary in attempting to lay down the general guiding principles for defence against raid under varying conditions, and the preparations necessary in time of peace.

The conclusions come to may be summarised as follows:—

1. The need for more care in the first instance in selecting the best lines of defence.

2. The necessity of making full use of the opinion of military experts on the spot, by making any scheme for defence, as regards armament and sites originate with them.

3. That economy as regards light should not be considered a matter of importance.

4. That a simple look-out and signal system, in some cases apart from, and independent of, that connected with the examination anchorage and supporting battery, is necessary.

5. That more attention should be paid to the physical qualifications of men, in selecting them for work with Q.F. guns.

6. That these men, once told off, should regularly be trained at, and fire their annual prize firing from the guns they would have to man on mobilization.

7. That the auxiliary forces should have all the practice possible with the guns they are told off to on mobilization, and should be familiarised with every conceivable form of attack they would have to cope with in war time.

8. That the annual allowance for practice should be increased, and a compulsory reservation of a fixed sum be made for periodical aiming-rifle practice throughout the year.

9. That employments should in no case be allowed to interfere with the military efficiency of the soldier.

10. That young officers should be thoroughly trained in what is apt to be considered I.O.M's work only.

11. That gun-layers, who are really crack shots, should be offered sufficient inducement to retain them in the Service.

12. That every effort should be made to enable night practice with electric light to be carried out, and practice batteries erected where necessary.

13. That all questions arising at any time as to possible manœuvres on the part of an enemy, or as to possible improvements in our own system and appliances, should be at once made the subject of experiment.

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Assuming the probability of raids by a Foreign Naval Power what are the best preparations to repel them so far as the construction, armament, and organisation of our Coast Defences are concerned?

BY

COLONEL P. SALTMARSHE, R.A.

" *Unitate Fortior.*"

HIGHLY COMMENDED ESSAY.

INTRODUCTION.

Meaning of raid.

Definition of the term.

"Raid" is an English word which at first sight seems perfectly easy to construe, but sit down and attempt to write a clear definition of the term and difficulties are found to arise at once.

Any sudden dash at our defences with the intention of inflicting damage followed by a rapid retirement seems to partake of the nature of a raiding attack, for example two hostile iron-clads approach a dockyard at night, bombard it heavily for an hour at daybreak, and then bolt; does this come within the category of raid? It might be argued both ways, fortunately the drill book* comes to our rescue and calls it a "desultory bombardment," so we are able to exclude it from discussion.

Again seeking counsel from the same excellent authority, we find a raid defined as "a sudden attempt to penetrate the defences with a view to the destruction of shipping in the harbour or under construction, docks, coal, or stores," the limits of our inquiry are thus happily narrowed.

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*"Garrison Artillery Drill," 1899, Vol. I., p. 151.—*P. S.*

Examples from history.

History helps us but little in the consideration of our subject, at any rate as far as sea raids are concerned. Torpedo-boat attacks are the successors of the "cutting out expeditions" of old, but as the latter were carried out under totally different conditions—the element of suprise alone being common to both—they are of little use for illustrative purposes.

The examples of successful torpedo-boat descents on vessels at anchor in inland waters, such as the destruction of the *Blanco Encalada* in Caldera Bay in 1891,* the sinking of a Turkish gun-boat in the Danube in 1878,* and the spirited dash of the Japanese flotilla at the Chinese war vessels in Wei-hai-Wei harbour in 1894, when with a loss of two boats only out of fifteen, fourteen men killed and thirty-one wounded, four hostile vessels were sunk,† though they show what torpedo craft when well handled can effect, and though they emphasize the necessity of a well organised defence, teach us but few lessons with regard to the same, for in no case did shore batteries assist the threatened vessels.

When raids are likely to be attempted.

At Santiago, the Americans never attempted to enter the harbour. Though our coast defences are liable to raiding attacks at any time during hostilities, and naval manœuvres have proved that torpedo craft can generally elude a blockading squadron at night,‡ the following seem the occasions on which we may chiefly expect them:—

1. Immediately after, or quite possibly even before the declaration of war.§
2. When, though we still have command of the sea, the enemy by clever strategy have drawn off our ships from the proximity of some important dockyard.
3. When we have temporarily lost command of the sea.

Raids at the commencement of hostilities.

The first is perhaps the most likely, for if an enemy meant business he would probably declare war as soon as or perhaps before we issued orders for mobilization, well knowing that it takes us a day or two to assemble our Militia and Volunteers whose services we so much depend on for manning our coast defences.

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*Major F. B. Elmslie, Duncan Gold Medal Prize Essay, R.A.I. "Proceedings," Vol. XX., p. 348.—*P.S.*

†"China—Japan War;" Vladimir, p. 281, *et seq.*—*P.S.*

‡"Naval Manœuvres, 1895;" R.A.I. "Proceedings," Vol. XXIV., p. 324.—*P.S.*

§For hostilities before declaration of war, see statistics by Colonel Maurice in 1883; R.A.I. "Proceedings," Vol. XX., p. 348.—*P.S.*

He would also know that booms and mines are not likely to be laid out until the last moment.

Such raids would be carried out by torpedo-boats and destroyers, perhaps too in the future by submarine craft; it is not likely the enemy would care to risk, at this period at any rate, larger and more valuable vessels; one cruiser or fast steamer might perhaps accompany the lighter craft for the purpose of breaking the boom, unless the adversary could count on its not being in position.*

Flotillas of torpedo-boats can be assembled without attracting much attention at foreign ports, the proximity of which to our southern dockyards enables a dash over and attack to be made during the hours of darkness, such flotillas would in all likelihood be well on their way before war was formally declared.

Impudent raids.

Raids by small landing parties with the object of destroying our Brennan installations, electric lights, and Q.F. guns may be expected at the same time, especially if our opponents see the chance of bringing them off before the infantry defence, which consists for the most part of Militia and Volunteers, is properly organised.

Raids during the temporary absence of the fleet.

A raid when the enemy considers himself safe from an immediate attack by our Navy would assume a different character.

In this case torpedo-boats might be accompanied by cruisers which would support the dash in of the lighter craft by a heavy fire on the Q.F. batteries and the electric lights of the defence, which in many cases they could do without entering the lighted area themselves.

Raids when we have temporarily lost command of the sea.

A raid when we have temporarily lost command of the sea would again be made under quite different conditions, here the enemy is for the time being safe from our Navy, and if from the presence at the objective dockyard of war vessels being refitted, or for other reasons, he considers it worth while, he may supplement the torpedo-boat attack by a bombardment of the fortress and docks; it is questionable perhaps whether such operations come within the scope of the present essay; though any sudden dash by torpedo-boats and other light craft through the inner defences, even if only an incident of the general attack, may be considered a raid.

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* "Some Naval Officers consider that a heavier vessel would always accompany the torpedo-boats."—"Value of torpedo-boats in warfare;" by Commander Bacon, R.N., "Brassey's Naval Annual," 1896, p. 156.—*P.S.*

Raiding attacks by land.

Landings of a raiding nature are not unlikely to accompany the second and their phase of naval operations just described.

Such landing parties must be of considerably greater strength than those I have suggested may be expected during the 24 hours or so following the declarations of war, for we shall have had time to mobilize our Militia and Volunteers by now, and the whole of the coast line in the proximity of our forts and batteries will be well patrolled and guarded; on the other hand the absence of our war vessels enables our opponent to transport over in safety a force which he hopes is strong enough to hold in check the infantry defence while batteries, search-lights, &c., are being destroyed.

Such attacks Mr. Jane tells us the French contemplate in the future even while our fleets are "in being," though from the discussions following his lectures, I gather that under the latter condition English naval officers hardly agree with him.*

The above being the kind of raids to which our ports may be specially subjected, we must now consider the best means of dealing with them.

PART I.

Construction and armament.

Heavy ordnance.

Heavy guns of a modern type may be sometimes used on the occasion of a raid, as for example, when a larger vessel attempts an entrance to break the boom, or the torpedo-boat rush is supported by fire from battle-ships or cruisers, but as they are unlikely to be located for this purpose only, they hardly come within the scope of the present discussion.

Lieut. Colonel Elmslie, in his prize essay, recommended heavy guns loaded with shrapnel being fired in salvos at torpedo-boats,† but this was 12 years ago and so many Q.F.'s have been placed in position since then that his suggestion need not seriously be discussed.

Defensive equipment against sea raids.

To repel raids by sea therefore the following may be considered:—

1. Q.F. guns.
2. Heavy R.M.L. guns (special case.)
3. Field pieces (under very exceptional circumstances.)

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* R.A.I. "Proceedings," Vol. XXIX., p. 28.—*P.S.*

† R.A.I. "Proceedings," Vol. XX., pp. 356 and 363. Refer also to remarks by General Richardson, p. 30.—*P.S.*

4. Booms and obstacles.
5. Brennan torpedoes.
6. Boat mines (now under consideration.)
7. Search-lights and other illuminants.

1. Q.F. guns.

4.7 inch and 6 inch B.L. Mark VII. guns.

Though the 4·7″ Q.F. and even the 6″B.L. Mark VII. guns would probably be fired at torpedo craft if their services were not required elsewhere at the time, and though they would be most useful in replying to heavier vessels supporting a raid or attempting to destroy the boom, it is unlikely they would ever be placed in position with these ends only in view and they need hardly therefore be considered in connection with a raiding attack pure and simple.

We have thus to deal only with light Q.F. armament.

The 6-pr. Q.F. gun.

The 6-pr. Q.F. has some advantages over the 12-pr. notably in rapidity of fire and easiness of shooting with the percussion lock, but the small size of its projectile renders it much less effective, and likely to be added to in the though existing guns may be left in position their numbers are not future.

The 12-pr. Q.F. gun.

The 12-pr. Q.F. with automatic sights seems the ideal weapon for dealing with torpedo-boats and destroyers.

The present pattern has, however, two defects in its equipment.

Want of improvement in the electric firing gear and percussion lock of the 12-pr. Q.F. gun.

(*a*) The unreliability of the electric firing gear.

(*b*) The inconvenient percussion lock. It must not be forgotten that every time a gun fails to go off, not only are its services lost for sixty seconds at least, a serious matter in a torpedo-boat attack at night, but it has a demoralizing effect on the layer.

In 1901, the writer saw misfire after misfire occur, though instructors of gunnery and range-finding as well as other experts were present when the gear was tested before practice. Last year, owing to improved cables and a better insulation of the striker, they were much less frequent and several series were sometimes fired before one occured, but extraordinary precautions were taken, precautions which in war, especially at night, might hardly be possible.

It is questionable therefore whether gear which requires such exceptional care and attention is desirable, and whether, if it cannot be greatly improved, it is not better to trust to percussion firing; unfortunately the arrangements for the latter with the 12-pr. Q.F. are clumsy and inconvient, the layer having to pull the trigger behind his back; some method which will admit of its being pulled on one side as with the 6-pr. Q.F. should, if possible, be devised.

Siting and construction of Light Q.F. Batteries.

Siting of Q.F. batteries.

This must depend in a great measure on the configuration of the neighbouring coast line and the character and extent of the bay, creek, or estuary in which the dockyard to be protected is situated.

Advantageous sites for Q.F. guns.

The ideal approach to a harbour from a defender's point of view is by a long and narrow entrance protected by successive batteries which expose the raiders to a fire of some duration before they reach their objective.

It would be interesting to give examples, but this can hardly be done without touching too closely on the defence schemes of individual ports.

Such favourable conditions are, however, not always met with.

Disadvantageous sites.

Torpedo-boats with light draught are not dependent at high tide on the main channels, and can usually get within comparatively near proximity to a harbour before they come under the search-light beams of the defence.

This necessitates the Q.F. guns which have to deal with them being all sited in the immediate neighbourhood of the harbour mouth, an unfavourable condition of defence in many ways, for not only is the enemy under fire for a short time only, but guns and dockyards being close together, shells which miss one may easily take effect on the other.

Consistent therefore with effective fire Q.F. batteries should not be too much crowded together.

Naval opinion to be asked for locally.

When sites for batteries are being considered, the opinion of naval authorities on the spot might be useful.*

Number of guns in a battery.

It is a mistake I think to place more than four guns together, the fewer the number in a battery the steadier will be the fire and the better the observation, moreover if a number are together, many may be out of action at the same time when echelonning is excessive.

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*See remarks by Lord Charles Beresford on the subject; "Nineteenth Century Magazine," February, 1897, p. 181.—*P.S.*

Heights of batteries in connection with auto-sights.

In constructing a battery on the sea level, as so many of ours are, it should never be forgotten that every foot of height is an advantage when automatic sights are used.

The present pattern requires a minimum height of 20 feet;* many of our low coast batteries allow little if anything over this at high tide, the time of course when torpedo-boats would make their attempt; with 24 feet the extreme range for accurate firing is 1,100 yards,† and with 30 feet 1,300 yards.†

Emplacements should be so engineered that the guns are at least 25 feet above the water at high tide, and if a few feet higher so much the better.

In day firing from a low site, auto-sights do not seem to give any markedly better results than ordinary ones, in fact at competitive practice many B.C.'s if left to themselves prefer layers and setters, but at night the superiority of the former is beyond dispute.

Frontal protection.

A weak point in the construction of our Q.F. batteries is their lack of frontal protection, but it is difficult to give it without narrowing the fire area, moreover at long ranges they afford but small and not very visible targets, and if an enemy once got in close the men would be driven off the guns in any case.

Protection in rear.

As regards protection in rear, there is a growing feeling among R.A. officers—witness General Maurice's remarks after Mr. Jane's lecture at Woolwich‡—that our works are often inadequately guarded on the land side.

Q.F. batteries are frequently enclosed by an open iron fence only, affording the gunners no protection whatever from musketry fire in the rear.

If the infantry defence is weak as it probably will be during the first 24 hours or even 48 hours of hostilities, raids on our Q.F. guns and electric lights by small parties of determined men are to be expected. Such parties will naturally attack in rear, the gunners may have to defend themselves, and if protected by open fencing, only, will be shot down, and the guns put out of action or even blown up.

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* "Garrison Artillery Drill," 1899; Vol. I., p. 142 g.—*P.S.*

† "Garrison Artillery Training," (provisional), p. 78.—*P.S.*

‡ R.A.I. "Proceedings," Vol. XXIX., p. 49.—*P.S.*

The capture of Banda Neira in 1810 by a night surprise.

An instance of a successful surprise at night is afforded by the capture of Banda Neira, the seat of the Dutch Government in the Spice Islands by Captain Cole, R.N., in 1810.*

The latter landed, his men, less than 200 in number on a dark and squally night, took one battery in rear by a sudden dash, and rushed the citadel as it opened its gates to admit its own Governor, the other forts thereupon surrendered.

The garrison consisted of 1,500 men, and there were 52 guns in position, so we have a striking example of what a few determined men can do.

If not actually inside a fort, batteries should surely be protected in flank and rear by a loop-holed wall with strong gate, this will guard the gunners against surprise, and if the raiding party is, as it probably will be, a small one, enable them to hold their own.

The above too is an argument in favour of the retention of the carbine by the R.G.A.

Shelters in Q.F. Batteries.

All Q.F. batteries should be provided with shelters† for one relief (*see* under "Organisation") and one officer per group in very close proximity to the guns themselves.

There is no reason whatever, if mobility is not a factor, why men should not enjoy shelter and comfort when not actually employed, and they will do their work all the better if such is provided, especially as the guns may have to be manned continuously for many months.

A recent War Office letter suggests that reliefs on the guns should lie out under waterproof sheets, &c., but it is hoped that this may be reconsidered, as if the shelters themselves are within a few yards of the guns, a watchman on each seems all that is necessary. A gun layer's hand and eye would be all the steadier if he has not been lying out in inclement weather.

Heavy R.M.L. guns and special case.

Very effective results on torpedo-boats at ranges up to 800 yards are believed possible with heavy R.M.L. guns firing special case.‡

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* James' "Naval History," Vol. V., p. 321.—*P.S.*

† The question of shelters is not quite a new one, Colonel Richardson advocated them in 1893; R.A.I. "Proceedings," Vol. XX., p. 26. It is only within the last year or so, however, that any action has been taken in the matter.—*P.S.*

‡ The 10" R.M.L. case contains 50 steel balls, each 3 lb. 9 oz. in weight.—*P.S.*

It is unlikely that such weapons would ever be specially installed for this purpose, existing ones only when suitably located being made use of.

Good positions for the above.

The most suitable position is at the narrow entrance of an harbour on inland waters, and the best way of employing them is to lay them on fixed points which the torpedo-boats are expected to pass over, and by position-finders or other suitable means to fire them by electricity from the top of the fort or other convenient post of observation.

By keeping the guns loaded and moving men from one to the other the *personnel* can be reduced to a minimum.

Trial of special cases at Shoebury.

Experiments were made at Shoeburyness in 1895 to test the results obtainable with these projectiles. A 9″ R.M.L. gun was used, the case shot containing 35 chilled iron balls of about 3 lb. each in weight.

The results were not altogether satisfactory, as an average of only two balls per round penetrated a ½″ steel target 400 feet in area at 400 yards, and only one per round a target of the same description but 720 feet in area, at 600 yards.

As these case have since been improved by the substitution of steel balls for iron ones, further trials are desirable.

Care should be taken that the retention of obsolete guns for the above purpose is not used as an argument for reducing the modern gun armament, for the are probably of little or no use except for firing case.

Field guns.

Possible employment of field guns against torpedo-boats.

Though the employment of other than coast defence artillery is hardly contemplated against torpedo-boats, occasions might arise when the field pieces belonging to the movable armament, or even the guns of a field battery, if their services are not required elsewhere at the time, should be used, especially if the defence is weak in Q.F. equipment.

Booms and obstacles.

Booms.

An example of the effective use of a boom is found in the operations at Wei-hai-Wei during the Chino-Japanese War.

Boom at Wei-hai-Wei.

The Chinese had placed across the mouth of the harbour a boom consisting of baulks of timber connected by wire hawsers, and held in position by chains and anchors.

Although this boom was unprotected by shore guns, the Japanese torpedo-boats three times—on 30th and 31st January and 3rd February, 1895—failed to get through it, and it was only at the fourth attempt they succeeded.*

Position and construction of a boom.

The natural position at first sight for an obstacle of this kind is at the narrowest part of the entrance to an harbour, but the tide is frequently to strong at such points to admit of its being placed easily and rapidly in position.

If the channel is too wide for a single span, it is divided into sections which are kept in position by anchored vessels or dolphins, and this method has the advantage of allowing the greater part of the boom to be laid out while one section is kept open for traffic; it is in fact questionable whether this plan should not always be adopted whenever practicable.

Necessity of laying out booms in peace time.

The obvious necessity of training in peace time those responsible for laying out a boom in war time is not sufficiently recognised. At one of our great dockyards, a boom which has been in existence for 11 or 12 years has to the best of the writer's knowledge never been put in position, the reason given being that traffic, which could easily be diverted for a day or two in another direction, would be interfered with. Practice in laying out this boom is all the more necessary as the tide at the harbour mouth is a very strong one.

Protection of boom by Q.F. guns.

It is insisted on, and very properly insisted on, in the "Garrison Artillery Drill"† that booms should be well protected by Q.F. guns which are required not only to deal with torpedo-boats attempting to enter the friendly channel, but also to destroy the swift launches the enemy may employ to break an entrance through the obstruction with dynamite.

It is almost needless to observe that such guns must have a clear water area to fire over, and yet there are places—it would not do to give chapter and verse—where the neighbourhood of the boom is considered a nice quiet anchorage for coal hulks and such like craft which by masking gun fire and electric light would afford excellent cover to torpedo-boats and launches. *See* further under "Co-operation between Army and Navy" page 58.

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* "China—Japan war;" Vladimir, p. 276.—*P.S.*

† "Garrison Artillery Drill," 1899, Vol. I., p. 176.—*P.S.*

Temporary booms and obstacles. A temporary boom is easily constructed by anchoring vessels across the fair way and stretching chains and wire hawsers between them. It is unlikely we shall ever take the desperate measure of sinking vessels across a channel as the egress from as well as the ingress to the harbour is thereby obstructed; the enemy are more likely to attempt this as the Americans did at Santiago; we may, however, narrow the channel, and thus make it easier to defend by these means, or we may, when two channels lead to a harbour or inland water, think it desirable to close one of them; the north channel leading to the western entrance to the Solent is a good example.

Brennan torpedoes. The R.E. inform us that it has not yet been definitely decided whether the Brennan is to be used against torpedo craft, it would probably depend on the number of torpedoes available; it would, however, be undoubtedly employed against any vessel of larger size attempting to pass with a view to breaking the boom.

A Brennan installation, if not actually within the walls of a fort, should have adequate infantry protection, for its machinery being so very easily destroyed, it would naturally be one of the first objectives of a raiding party.

Boat mines. These have been adopted by the Navy, and are, we are informed, under consideration by the R.E. The discussion after Mr. Jane's lecture shows that there is a great difference of opinion as to the value of submarine mines in general, but if we admit their utility, these boat mines would seem a desirable adjunct to our defence against raids, especially if Q.F. guns and electric lights have suffered from the enemy's fire; they are easily and rapidly put in position, at the same time they would undoubtedly complicate the arrangements for the safe navigation of friendly vessels.

Electric lights. As it is hardly probable that raiding attacks will, except perhaps in foggy weather, be attempted otherwise than at night, it is necessary that the fire area of the Q.F. guns be illuminated as much as possible.

The arrangements described in "Garrison Artillery Drill"* seem in most respects satisfactory, but many gunners think that the advanced or sentry beam, which should be a search-light and not fixed, ought to be under the control of the C.R.A., whose interest it is above all others to have the earliest information of the enemy's movements, and who should be able to manipulate the light in question in what he considers the best way to obtain it.

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*"Garrison Artillery Drill," 1899, Vol. I., p. 175.

Electric light tactics.

Our general principle of course is to keep the fire area continuously illuminated by all lights, but would it not be feasible, by aid of the shutters with which the lights are provided to adopt some sort of tactics by which the enemy would be worried and confused?

For example:—"A" "B" and "C" "D" are four lights. "A" being the outside one, presuming the attacking boats must pass through the area illuminated by "A" "B," would it be possible to shutter off "C" "D" until they are required?

The enemy passing through "A" "B" would see dark water in front of him and might slow down, especially if any boats had been hit and holes required plugging, in any case fresh lights turned on him suddenly would bother his helmsmen.

It would depend on local circumstances and the number of installations whether these tactics could be carried out safely, but naval officers say they would be exceedingly annoying, and much object to our trying them at peace manœuvres.

Vulnerability of electric lights.

Electric lights are somewhat vulnerable both in front, and if they are not within the limits of a fort, also in rear.

Buoys are not removed during war, hostile vessels can therefore pick one up at night and by aid of their charts will have the range to a yard, the lights themselves give an excellent line, and some of them at least are not unlikely to get knocked out by the enemy's fire.* It is worthy of consideration whether they could not be at least partially protected by iron casemates or some arrangement of armour plates round the apparatus.

As regards protection in rear, the arguments already used for enclosing Q.F. batteries by a fence which is not penetrable by musketry fire, apply quite as forcibly to electric lights which are sure to be one of the objectives of a land raid.

Auxiliary illuminants.

There seems no reason why batteries should not be supplied with auxiliary illuminants such as light balls, rockets, and light parachutes, if they can be fired by rockets, not only would they be useful if the electric light was put out of action, but they might materially assist the defence in the event of an attack being made in the rear.

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*For corroboration refer Mr. Jane's lecture, R.A.I. "Proceedings," Vol. XXIX, p. 37.

Rockets too might be used for signalling and alarm purposes if other communications broke down.

Raids by submarine craft.

Raids by submarine torpedo-boats must ere long be seriously considered; that the French think them feasible is evidenced by Captain Heilmaun's report to the Minister of Marine on the results of trials with these craft last summer,* in which it is stated "that the submersible type can visit an enemy's harbour and attack ships that have taken refuge therein."

Such raids will indeed be difficult to meet as the boats will pass through or rather under the lighted area secure from the fire of our Q.F. guns, and the boom as constructed at present will be no obstacle.

A net work of boat mines at different depths, and torpedo netting stronger than that used by the Navy seems the only means of dealing with them.

Communications.

Though Q.F. batteries at night are not under control of any fire command, it is desirable they should be able to communicate readily with the F.C., for example heavy casualties in *personnel* or *matériel* may require replacing, moreover useful information as to the enemy's movements, number of attacking boats, &c., can often be afforded an F.C. by an outlying battery.

General O'Callaghan instances a case at manœuvres in Malta in 1901, where boats got through the defences simply because the F.C. had no means of communicating with some of his guns.†

Telephones therefore from the F.C's posts to all Q.F's are desirable, though except for alarm, or imparting necessary information they should be sparingly used.

New alarm circuits.

A new alarm circuit has been recently proposed; this will connect the sentry beam installation with the F.C's post and all Q.F. guns, and is so arranged that any of these can give the alarm to the others simultaneously, a gong in the shelter or other convenient place being sounded.

Raids by land.

Our defence against raids by land depends chiefly on the rifle, but there are one or two artillery adjuncts which may be touched on.

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* "Journal of the Royal United Service Institution;" Naval notes, Vol. XLVI., p. 1466.

† R.A.I. "Proceedings," Vol. XXVIII., p. 221.—*P.S.*

Machine guns.

To repel such raids, especially if on a large scale, machine guns on light traveling carriages are useful, and should be held in charge in all sub-districts. Such guns are sometimes located on fixed mountings in the proximity of our batteries, but as the invaders would of course avoid them, their value is questionable.

Movable armament.

The guns of movable armament need perhaps hardly be discussed in connection with raids pure and simple, though if the latter were in force, their services might be utilized.

If on the spot, they would of course be used against boat landings.

A rapid firing field gun is the most suitable, though for many years to come we can only hope to get the weapons the mounted branch have discarded.

PART II.

Organisation.

It is much easier to discuss organisation freely, than construction and armament.

Organisation.

In the treatment of the latter we have often to deal with that awkward point *un fait accompli*, which must have some effect on the mind of the writer; the former, on the other hand, can be modified or altered by the stroke of a pen or at most the installation of a new telephone.

Under organisation may be considered:—

1. The *personnel* required for defence against raids, viz., Artillery, Engineers, and Infantry.
2. Co-operation of the different arms.
3. Co-operation with the Navy.

Artillery.

Artillery organisation.

We depend of course to a great extent on our Militia and Volunteers for the manning of our coast defences, but it ought to be fully recognised that Q.F. armament must be in the hands of the regulars.

A Q.F. layer, and if automatic sights are not used the setter also, has great responsibility, the former has absolute control over his weapon, he traverse it, lays it and fires it himself, and on his nerve, steadiness, and eye-sight depends the efficiency of the shooting.

The necessity of Q.F. detachments belonging to the regulars.

Careful and continuous training and practice is necessary, and we could no more expect a Volunteer or Militiaman, with the limited chances at his disposal, to obtain the same results as a regular, than we could hope to see a sportsman who has a few days shooting in the year equal the feats of Lord de Grey.

Q.F. guns too may be required the first night of hostilities, before the auxiliaries shake down and get accustomed to their weapons, possibly before they arrive on the scene.

Putting accurate and rapid shooting aside, the great difficulty already alluded to of keeping the firing gear of these guns in order, as well as the great care required in the manipulation of the automatic sights renders it imperative that they should be in the hands of men who thoroughly understand them.

Wherever therefore Q.F. guns are installed their manning details should be provided by the regulars, and if the latter are not forthcoming, much as mixed detachments are to be deprecated, the gun layers at least should be provided by them.

Distribution of reliefs for Q.F. guns.

Though a single relief with a fair reserve for casualties is considered sufficient for guns which need not be manned continuously, light Q.F. guns which during the hour of darkness must be ready to fire at a moment's notice require the number actually necessary for their service to be always on the spot. Reliefs must, therefore, be arranged.

The following seems a convenient system, it has been already adopted in one district and works well:—

The manning allowance for light Q.F. guns* admits of some 16 men being detailed for each; these 16 men are divided into four reliefs of four men each, this number being sufficient to serve the gun efficiently if the ammunition is previoulsy placed in readiness.

The first relief will always be on the gun or in a shelter in very close proximity, in any case a watchman will remain on each piece.

If the barracks are within say a quarter of a mile, the second relief can sleep there, but in their clothes and boots; should their rooms be over that distance and there is no other convenient place, the shelters should be large enough for two reliefs. The third and fourth reliefs will sleep in barracks in the usual way. If the barracks are above, say a mile from the guns, hut or tent accommodations must be provided nearer at hand, the former of course for choice.

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* War Office letter, 51 | Devonport | 8004 of 25 | 1 | 01.—*P.S.*

Q.F. details during the emergency period.

During the interval which elapses between the orders for mobilization and the arrival of Militia and Volunteer units, called in our defence schemes "The emergency period," the third and fourth, and even if necessary the second reliefs will be held in readiness to serve the most important of the heavy guns which the auxiliaries take over on arrival.

Fire tactics of light Q.F. guns.

Though in action the gun-layer must to a great extent be left to himself, some simple arrangement of distribution of fire seems neceessary; want of space prevents our entering into details, but any such scheme should be based on the principle that every effort ought to be made to sink the leading boats, for if they are destroyed or rendered unmanageable, not only will the passage of those in rear be obstructed but the moral effect may be considerable.

Defects of Artillery organisation with special reference to Q.F. guns.

There is one very serious defect in the present system of administration affecting the effective employment of Q.F. guns. I allude to the arrangements for providing foreign reliefs.

Effect of the present system of foreign reliefs on the efficiency of our Q.F. gun defence during the winter months.

It is of course necessary that our forces aboard be kept up to the full establishment, and as we cannot recruit at foreign stations, this can only be done by drawing on units at home. It is not, however, quite recognised that, while other branches of the army are unlikely to be employed at the commencement of hostilities with a European power, and that they will therefore have time to fill the gaps in their ranks before having to fight, the services of the Garrison Artillery may be required simultaneously with the declaration of war; neither is the fact quite appreciated that the special training, which recent improvements in our *matériel* necessitate, cannot be imparted in a few days or even a few weeks.

We know of two companies which during October and November last year lost practically the whole of their efficient gunners. They each manned on service eight Q.F. guns and were expected to keep up 32 layers apiece. When they had despatched their foreign reliefs, five layers in one and three in another were all that remained, and it need hardly be pointed out that after the officers' servants, his D.R.F. specialists and Q.F. layers are the last men a Major will part with, he will keep them by fair means, or foul if he can do so.

This wholesale denudation simply means that had we been raided in September, the service of the Q.F. guns in question would have been as effective as two zealous and capable Majors could make it; had, on the other hand, the attack come off in December, it would have been quite a different pair of shoes.

Of course the recruits which come in during the winter months are trained as rapidly as possible, but as the yearly practice is over, none of them will fire a shot until the following spring.

It is unfortunate that all our reliefs must be carried out in these months instead of being spread out over the year; this renders us, as far as our home coast defences go especially vulnerable between November and March, a fact which hostile powers in the future are not unlikely to take advantage of.

A proportion at least of foreign reliefs might be recruits who can learn their drill abroad as easily as they can at home.

Effect of the system of carrying out reliefs by groups instead of by districts.

Another difficulty in our administration, and the statement is made with all due respect, is the system by which foreign reliefs are arranged by groups instead of by districts.

Under the present arrangement for example, a company manning Q.F. guns in war, which Militia and Volunteers have little or no experience in handling, may have most of its men sent abroad, while another told off perhaps to armament which the auxiliaries are accustomed to is almost untouched.

This could not happen if the C.R.A. of the district selected the men for reliefs.

The above points are worthy of serious consideration as they gravely affect the efficiency of our Q.F. defence against raiding attacks.

Light Q.F. gun practice.

Practice from light Q.F. guns.

It is perhaps hardly intended that details of drill and training should be discussed in the present essay, but we venture to bring forward two points which might be improved on as far as Q.F. armament is concerned.

The first is our competitive practice, now excellent in many respects as is the system under which this is at present carried out, it has this defect; the whole arrangement for classification is based on a broadside or nearly broadside target though the winding in gear on our launches enables us now in many places to give approaching shots at almost any angle, thereby making the shooting far more varied and "sporting." Modifications in the practice regulations are desirable in this respect.

Carbine shooting as a training for Q.F. practice.

The other point is carbine shooting, the value of which as an adjunct or rather preliminary to practice over sea ranges, with special reference to Q.F. training, is hardly appreciated as much as it might be.

Even the stereotyped musketry course, drawn up almost entirely from an infantry point of view, helps a company C.O. in the selection of men likely to become good layers, give him a freer hand in the distribution of the ammunition and he will do a great deal more towards making the land range a training ground for the sea one.

For example, as rapidity as well as accuracy is a great factor with a Q.F. gun, he would probably apply the test of "hits per minute" to carbine practice, making certain selected shots fire as rapidly as they can at say the 200 yards target, and then choosing his layers from those who made the greatest number of hits in a given time independent of the quantity of ammunition expended.

Royal Engineers.

R.E. organisation.

The difficulty the R.E. have in organising the *personnel* required for their lights is simply lack of men.

Manning details for the electric lights insufficient.

We believe we are right in stating that at no single important fortress at home have they sappers enough on the spot to provide even one relief if all lights are being manned simultaneously, as of course they will be in war, especially if any of their men are engaged with the submarine mines at the time.

They depend largely on Militia and Volunteers and should be quietly reinforced by these auxiliaries before actual mobilization is ordered.

Search-light tactics have been discussed under "Construction and Armament."

Infantry.

Duties of infantry defence.

On the Infantry, the Artillery and Engineers rely for protection from raiding attacks in rear, and attempts to destroy their guns, Position Finding cells, and installations.

Mr. Jane in his now well known lecture commented on the unprotected state of our coast defences on the land side, and hinted that we did not sufficiently recognise their vulnerability in this direction.*

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* R.A.I. "Proceedings," Vol. XXIX., p. 40.—*P.S.*

Sufficiency or otherwise of infantry defence.

Colonel Barron in the discussion which followed tried to ease our minds on the subject,* but some of us think there is a great deal in what the lecturer urged. If what Colonel Barron intended to convey was that local authorities are doing their best with the means at their disposal, he no doubt is right, but are these means usually adequate?

During the early days of hostilities at least we have some cause for anxiety.

The secrets of course of our defence scheme cannot be discussed, but it is well known that our general principle is that all regular infantry units join the field army immediately orders for moblization are issued, the infantry defence of our coast fortresses being greatly left in the hands of auxiliaries.

Now is it quite wise to withdraw all the regulars before the Militia and Volounteers settle down in their place, get accustomed to the locale and learn somewhat of their duties? Is the necessity of at once assembling the whole of the field army so urgent that units stationed at important naval bases cannot be left there for the first week or so of hostilities?

It is during these first days few that the danger is most acute, as auxiliaries have only just arrived who are quite ignorant of the ground they have to defend,and who may have seldom if ever been practiced in night operations.

Training of the infantry defence.

Necessity for training auxiliary units at their mobilization centres.

A point which cannot be too strongly urged is that auxiliary units should go through their annual training at their moblization stations. We are well aware of the great difficulty there is in inducing some of them to willingly leave their own districts for their camps on account of social and recruiting exigencies, but these difficulties must be overcome. Both Artillery and Infantry Corps should train at their moblization posts at least every other year, and during the year in which they do not so train all officers should be brought to these places at the public expense, be shown over the ground both by day and night and have the position of the picquets and patrols carefully explained to them; they should all be in possession of maps of the locale, and should be encouraged to work out tactical problems based on landing attacks and raids therein.

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* *Ibid.*, p. 44.—*P. S.*

It is of course the rule that Artillery Militia do train once in every three years at the works they man on service, and Volunteer Artillery in many cases every year, but auxiliary infantry hardly ever, though it is nearly if not quite as important that they should do so as well. This is further discussed under "Co-operation."

If an apology is needed for including in this essay, questions which at first sight appear to belong more to coast defence in general we would point out that it is during the first few nights of hostilities, when raiding attacks are more likely to take place, that lack of previous training will be chiefly felt.

Co-operation of the different arms.

Co-operation of the three arms.

"We (the gunners) suffer much from want of co-operation with other branches of the service which does not tend to increase efficiency of defence."

The above are the remarks of the Inspector-General of R.G.A., in his first annual report.

The I.G. R.G.A.'s first annual report.

The I.G. R.G.A. then comments on the disinclination of the R.E. in many cases to give the R.A. the details of their mine fields or even to disclose to them their whereabouts.

A recent decision however of the War Office* has put this matter on a better footing.

As regards working together, there should not be, neither is there generally, any difficulty, but as we have already pointed out, the R.E. can seldom run the whole of their lights at once without extraneous help.

The I.G. R.G.A. also alludes to the little training infantry get in coast defence work, and the Commander-in-Chief in forcible terms endorses his remarks on the necessity of improving matters in this respect.

Meaning of combined mobilizations and their rare occurrence at home.

Though Artillery mobilizations partial or otherwise are of not unfrequent occurrence we very rarely see the three arms requisite for the defence of a coast fortress brought together at home. During 13 years continuous Garrison Artillery service, the writer has never seen this done, and believes he is right in stating that at our most important naval base, the complete defences even on the seaward side have never been mobilized together. The reason has been of course the difficulty in collecting at one time the different auxiliary units alloted to the defence, especially the infantry ones which are almost wholly composed of Militia and Volunteers.

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* War Office letter Conf. D. 191. of 26 | 11 | 02.—*P. S.*

Now the Commander of one section in this fortress has in war some thousands of auxiliary infantry under his command, these infantry are alloted chiefly for the purpose of defending some miles of coast line, and protecting Q.F. batteries, search-lights, water supply, &c., from sudden raids; now how can this Commander, an R.G.A. officer probably, or his staff hope to handle and dispose of such a body of men to the best advantage if they have no practice beforehand?

If they are not trained *on the spot* in peace time, how can these Militia and Volunteers be expected to do good service in war?

Yearly mobilization of the units required for defence against early raids very necessary.

Those units of the *personnel* of a fortress whose services are most likely to be required at the commencement of hostilities, as for example, Q.F. detachments, electric light engineers, and the infantry detail necessary for their protection against raiding attacks, should be mobilized really every year if only for a few days.

Big fortresses abroad like Gibraltar and Malta have permanent garrisons of considerable strength which the General Officers Commanding can mobilize on their own initiatives.

Co-operation with the Navy.

Co-operation with the Navy. Lord Hartington's Commission.

This was a point specially emphasized by the Hartington Commission.* Want of space prevents quotations at length being made from their report, but attention may be drawn to para. 7, 9, 10, 11, and 12, where the want of a proper understanding between our Naval and Military forces is strongly commented on, and especially to para. 13 where the then conditions of affairs is described as *unsatisfactary and dangerous.* Has it been bettered since?

Lord George Hamilton's speech on the subject in 1893.

The policy of entrusting the defence of our harbours to the Army may be a wrong one,† but as long as it is in force co-operation between the services is one of the most important features of satisfactory organisation.

The Navy when not at sea looks to the Army, and especially to the Artillery branch, for protection.

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* Royal commission to enquire into the Civil and Professional administration of the Naval and Military departments, dated July 10th, 1899.—*P. S.*

† Speech of Lord George Hamilton, March 7th, 1893.—*P. S.*

On the Army devolve the duties of guarding the dockyards, harbours, and anchorages whose security is so essential to the sister service.

It follows therefore that there are many questions which must be settled by mutual agreement and co-operation.

Questions for co-operation between the services.

The most important of these are:—

1. The regulations for the ingress and egress of friendly vessels into and from defended ports during hostilities.
2. The arrangements for laying down mines.
3. The employment of booms and obstacles.
4. Installation of electric lights.
5. Removal of buoys.
6. Removal of coal hulks and other anchored vessels off fire areas.
7. Employment of guard-boats.
8. Combined training.

Regulations for the ingress and egress of friendly vessels.

Admittance of friendly torpedo-boats at night.

These generally speaking appertain more to the defence of the port as a whole than to mere raiding attacks. What however we must discuss in the present essay is the question of whether or no we are to allow friendly torpedo-boats into the harbour at night.

The present ruling is that all vessels of this class are to be fired on during hostilities, and as it is impossible for our gunners to discriminate between friends and foes after darkness sets in, this seems to be the only safe policy;* no satisfactory system of arranging for their entry into the harbour at night, at any rate unaccompanied by the escort of a larger vessel, seems possible.

Lessons on the subject from the 1901 manœuvres.

On the other hand one of the few things we gunners learnt from the Naval Manœuvres of 1901 was that the Naval Commander-in-Chief is not unlikely to insist on his scouts, who may have important and urgent information to deliver, being admitted at any time; such information too might be of the utmost importance to the officer in military command, and some scheme must be devised for sending it in. Again partially disabled boats of our own may require immediate attention.

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* "Everything that cannot make itself unmistakedly known at night, should be ruthlessly sunk, for in these days of fast torpedo-boats there is no time for consideration."—"Defence of a fortress;" by Col. Richardson, R.A.I. "Proceedings," Vol. XX., pp. 26 and 31.—*P.S.*

During the manœuvres in question the above mentioned rule was modified by a provision enabling torpedo craft to be admitted at night by local arrangement.

Lieut. General Owen, the military umpire in chief, commenting on the above states:—

"The exception made as to torpedo craft not being always fired at by night if local arrangements are made to the contrary opens the door dangerously at present. This point is the most difficult of all to deal with satisfactorily."*

Suggestions as to the admittance of friendly torpedo-boats.

We put forward the following suggestions with great diffidence as the question is so much a naval one:—

(*a*) That a friendly torpedo-boat having news to communicate should deliver it to the Commander of the examining vessel, who would signal it in.

The objection to this is that unless the message was signalled in cypher it would not remain confidential.

(*b*) That any friendly torpedo-boat wishing to enter the harbour, should be closely escorted at very low speed by some dockyard tug or launch well known to the gunners, and showing some preconcerted signal.

(*c*) That, where the configuration of the coast line admits, a small auxiliary harbour, in many cases a pier would suffice, should be constructed where a boat could land and deliver its message without running the gauntlet of the Q.F. guns.

Laying out boat mines.

This, so far as raids go, only refers to the possible use of boat mines which could only be put in position with the acquisecence of the Naval authorities. It is we believe a well known fact that the latter are not favourable to mines in general and the R.E. anticipate some difficulty in obtaining permission to use them during hostilities; some definite agreement on this point should be come to.

The employment of booms and obstacles.

The use of booms and obstacles.

It is very necessary there should be some clear understanding between Naval and Military officers on this subject. We seldom if ever see booms placed in position in peace time, and a doubt arises in our minds whether

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† Report of the military umpire-in-chief for Naval manœuvres of 1901, para. 27. d.—*P.S.*

it is really intended to use them in war. As we install Q.F. guns and electric lights to defend them, a definite policy on this point should be arrived at.

The same remarks apply to the closing of part of a water-way or an auxiliary channel.

The installation of electric lights.

This is a matter on which the Naval authorities have to be consulted, the glare of the lights frequently interfering with the navigation of vessels.

This difficulty is most acute at the actual entrance to a harbour where the Admiralty sometimes insist on having a considerable area of unlighted water.

It is not quite understood why, if lights are provided with shutters, which are only opened when required, *i.e.*, when a raid is actually occuring, they should be objected to.

Removal of buoys.

Possible removal of buoys.

Instances might occur when, in order to deceive the enemy as to ranges, it might be desirable to alter the position of buoys if this could be done without interfering with navigation; the Naval and Military authorities would have to agree on the question, and it ought to be carefully thought out in peace time.

Removal of coal hulks, &c., from the fire areas.

Removal of hulks off the fire areas.

This has already been alluded to on page 47. It is an important point.

The usual arrangement is that such craft will be taken away on the commencement of hostilities. This is not nearly definite enough, it will take some time to remove them, especially the coal hulks, and every tug and probably every man will be required elsewhere at the time.

Their removal should be one of the preparations we make before actual mobilization and some clear understanding on the subject between Naval and Military authorities should be arrived at.*

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*In support of many of the above remarks we venture to quote the following paragraph from the report of the Hartington Commission:—

"There does not appear to us to exist sufficient provisions for the consideration by either service of the wants of the other, it seems to be assumed without adequate ground that each will in time of need be prepared to give the assistance, &c."—Report of Lord Hartington's Commission, 1889, para. 12.—*P.S.*

Employment of guard-boats.

Duties of guard boats.

Every officer in naval command at an important dockyard has in war time certain vessels, torpedo-boats for the most part, allotted to him for patrolling purposes. Some idea of the sea area to be guarded by these boats, and their general duties should be known to the military commanders; his own tactic sare to a certain extent affected thereby.

Combined training.

This, though discussed last, is perhaps the most important question of all.

For some extraordinary reason the Navy at any rate in home waters, show a marked disinclination to join hands with us.*

Want of co-operation between the services as regards combined training.

Lord Charles Beresford in the article referred to, Gen. Owen in his report on the Naval Manœuvres of 1901, Gen. Slade in his first Annual Report, Mr. Jane in his well known lecture, and Colonel Barron, in the discussion which followed all comment on the want of co-operation in this respect between the two services. I am convinced that every R.G.A. officer fully agrees with them.

In spite of recent instructions, a naval officer rarely attends to witness practice from our batteries, and though soldiers and sailors are ever the best of friends, the latter do not show any great anxiety for our company at their quarterly firings.

What we most deeply deplore however is the unwillingness of the sister service to help us to test the effiicency of defences on which her ships when in harbour will have to rely so much for protection.

Army and Navy co-operate readily enough in all social questions, as the numerous service clubs in London, and recreation grounds at Portsmouth and elsewhere testify; at cricket, football, hockey, golf, or any other game we find no more eager opponents than the sailors, but if we challenge them to a professional contest we usually meet with a chilly response.

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* "I am sorry to say that during my experience in the majority of cases that have come to my notice where the Army and Navy have not combined or rather where difficulties have been raised to their combining in certain operations, almost invariably the difficulties have been raised on the part of the Navy."—Lord Charles Beresford in "Nineteenth Century Magazine," February, 1897, p. 181.—*P.S.*

Absence of Naval operations against coast defences at home.

Though attacks on the forts do sometimes take place at Gibraltar and Malta, we cannot recall one single instance of naval operations on a scale worth mentioning having been undertaken against any of our coast defences at home.

Attack on Portsmouth in 1890, forbidden by the Admiralty.

About 12 years ago such operations were contemplated at Portsmouth; a fleet was to go to sea for a week and subject the fortress to a series of attacks of all kinds not the least of which would have been the raids by land and sea we have been considering; the greatest interest was taken by all concerned, but at the last moment the Admiralty withdrew their permission.

Mark however the loss to us. At this time the positions for Q.F. guns and electric lights were being considered, and the defence scheme drawn up, what valuable information, information which might have seriously affected the installation of the former and the preparation of the latter, was lost when these operations were given up.

Naval Manœuvres, 1901.

It is true that sections of our coast defences are supposed sometimes to take part in our Naval Manœuvres, but the schemes under which the latter are carried out never oblige a fleet either to attack our forts, or to take refuge behind their guns. During the operations of 1901 not a round was fired from the land at any but friendly vessels.

Naval Manœuvres, 1890.

In the Naval Manœuvres of 1890, an hostile flotilla operating from the Channel Islands made a successful attack on a fleet in Plymouth harbour, but the forts took no part in the operations!*

Wanted, an enemy!

We gunners, or rather I should say coast defence garrisons, for Engineers and Infantry are as much affected as Artillery, labor under the enormous disadvantage of rarely being able to obtain an opposing force.

How dull and uninstructive it would be for our field troops if they always operated against an imaginary enemy, fancy manœuvres at Aldershot and Salisbury carried out on such lines! Is it not equally uninteresting to us to hammer away day after day at our work without any opponent.

Let us take an example from land manœuvres to illustrate what we require.

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* Prize Essay, Major Elmslie; R.A.I. "Proceedings," Vol. XX., p. 349.—*P.S.*

(*b*) The desirability of siting Q.F. guns as high as possible with special reference to sea level batteries.

(*c*) The necessity of giving Q.F. batteries rear protection.

(*d*) Further experiments with the special case fired from heavy R.M.L. guns.

(*e*) Protection for electric lights. Further consideration of their tactical employment.

(*f*) Improved communications.

2. As regards organisation.

(*a*) A modification of the present system of carrying out foreign reliefs in the Garrison Artillery, to ensure a sufficient number of layers and specialists being retained in the winter months for the efficient service of the Q.F. guns.

(*b*) A modification of the regulations for competitive practice to enable Q.F. guns being fired at approaching targets. Development of carbine practice.

(*c*) The better training of the infantry allotted to our coast defences.

(*d*) More frequent mobilizations of the three arms together.

(*e*) A better understanding with the Navy as to the admittance at night of friendly torpedo-boats, booms, mines, electric lights, clearance of fire areas, &c.

(*f*) The necessity of more thorough co-operation between the services in regard to combined manœuvres.

Conclusion. It may be considered that "Co-operation with the Navy" occupies too much space in this treatise, and that the subject perhaps has been unnecessarily drawn out; it is one however of such immense importance that no argument should be omitted which may tend to induce both services to recognise more fully the significance of the motto of their famous club.

[Reprinted from the Proceedings of the Royal Artillery Institution, July, August and September, 1903.]

Assuming the probability of raids by a Foreign Naval Power what are the best preparations to repel them so far as the construction, armament, and organisation of our Coast Defences are concerned?

BY

CAPTAIN J. C. HANNA, R.G.A.

"*Statio Bene Fida Carinis.*"

HIGHLY COMMENDED ESSAY.

CHAPTER I.

Introduction and general remarks.

The nature and amount of armament, both primary and secondary, in our coast fortresses will of course depend on the strategical and tactical value of the place, and on the nature of attack to which it is most exposed from its geographical position.

Our Defence Committee at Headquarters is responsible for selecting the various harbours to be fortified as naval bases, or harbours of refuge for our mercantile marine, and for apportioning the armament to each individual port according to the value that port is expected to have in war; the detail of the armament and defences generally being of course further determined by the consideration of existing artificial or natural protections (such as breakwaters or shoals) and on the conformation of the coast line; *i.e.*, if good sites are obtainable the number of guns may be fewer and yet adequate for the defence of the place.

But as this essay is confined to the question of construction, armament and organisation of our coast defences against *raids*, it will be necessary to seek a definition of the word raid and only deal in detail with that part of the armament, &c., which is primarily intended for use against such form of attack, assuming that the remainder of the defences are all that they should be for the requirements of the locality.

"Garrison Artillery Drill, 1899," Vol. 1, page 151, classifies the various forms of attack to which our coast defences are liable, the fourth of these being "Raid," and on the following page raid is defined as "a sudden attempt to penetrate the defences with a view to the destruction of shipping in the harbour, or under construction, docks, coals, or stores." To this might be added "or an attempt to cut off outlying batteries, signal stations, or defence lights."

Briefly then raids may be classed under two headings:—

(*a*) By sea.

(*b*) By land.

Of these, (*a*) will almost invariably be made by torpedo craft, and then either by night or in thick weather. It is very probable that such attacks may be made before formal declaration of war.

The second heading (*b*), is a more difficult one to define or guard against. It may be of any strength, from (1) a single boat's crew landed to destroy a signal station, cut a cable, &c., to (2) a considerable force of infantry, with field guns, and howitzers, landed outside the water area covered by the heavy guns of the fixed defences, intended to attack the forts or what they cover from the land side. It is clear that (1) may be expected in any state of sea power and also before the formal declaration of war, but that (2) could not be launched against us till a state of war actually existed, and not even then unless the enemy had at any rate temporary command of the sea, for as long as we had any destroyers afloat, they would be on the spot quick enough to cut off the transports that landed such a force before they could embark the troops again and get clear.

Let us then accept this definition as a basis to work on, and the general instructions on the following pages of the drill book just quoted, *i.e.*, that torpedo-boat raid would be met by the fire of the light Q.F. guns of the defence, assisted by the electric lights; with perhaps boom defences and mine fields thrown in, and that a land raid would be met by the infantry garrison with the guns of the moveable armament.

CHAPTER II.

Construction.

Fixed defences. Light Q. F. batteries.

The first point naturally to consider is the question of site, and there are several points to be considered in connection therewith.

It stands to reason that as torpedo-boat attack is chiefly feared by night, the water area covered by the guns must be illuminated—and therefore as the power of effective illumination is limited, that part of the harbour or approach thereto which can be effectively lit up must be selected for the light Q.F. defence. This will be the first and main consideration—then comes the consideration of height above sea level, if the limitations already mentioned afford any choice in the matter—with auto-sights it is a fairly safe principle to lay down that the higher the better, always provided that there is not a dangerous area of "dead water" left, except perhaps for very short ranges—but there are very few places where *too* great a height is obtainable. Next obtain as large an arc of fire as possible, for each gun, over the illuminated area.

These considerations, with the all important one of the difference in cost between different sites, will fix the positions for the batteries.

We now use concrete and not brick work or stone for all our fortifications. A solid drum of concrete is laid down and the pedestal firmly bolted down to it. This requires to be very carefully levelled. The terreplein at the level of the top of the drum should be sufficiently large to allow of the detachment having plenty of room to work. The top of the apron should be as high above the gun floor level as is compatible with getting the full amount of depression required. The front of the apron and the earth parapet or sand belt should slope down at a steeper angle than the extreme angle of depression required—for if not, when firing at very short ranges, the axis of the gun is nearly parallel to the slope of the parapet, and so little above it that the blast will cause such a cloud of dust &c., as to seriously impede the working of the gun. Providing sufficient height is obtainable to overcome the question of dead water in front, it is a mistake to raise the guns above the natural surface of the ground. Recesses must be provided, practically on the gun floor level, for a good supply of ammunition. Magazines should be as close to the guns as can be arranged.

Shelters for a complete detachment for each gun must be provided as close as possible, and should be as nearly on the same level with the gun floor as practicable. The officer also must have his shelter. The shelters need not necessarily be bomb proof. Nobody would be in them during action, and if they are knocked away some form of cover can be improvised pending their repair. A recent W.O. letter suggested "uralite" as a material to use, and it would seem to have several advantages. It is non-inflammable and does not splinter like wood. Moreover, being very thin, it offers practically no resistance and shells might go clean through it, leaving a clean hole, without bursting. The gun emplacements, magazines and shelters should be well lit by electric light. To ensure a quick turn out plenty of light is necesssary, and as long as the actual lights themselves are screened from the sea, the glow that they throw will be inappreciable when coming into the harbour in the glare of the fixed beams over the illuminated area. It is poor economy to try and save the cost of fixing an extra "oyster light" or two, and when there are perhaps six or eight or a dozen 30,000 candle power beams running, the extra power required costs practically *nil.*

A year or so ago there was an idea that some form of light lying down cover, actually on the gun floor, for three or four men was necessary in addition to the shelters, but it has been found so impossible to provide in all existing batteries, that the idea has been abandoned, and in cases where it is essential that men must be standing to their guns all night they must just brave the weather in the open. But these conditions do not prevail everywhere. In many places it is possible to have a sentry beam some way in front of the illuminated area, and with a sharp lookout kept (from both ends of it, if feasible) and a continuous alarm circuit from these lookouts ringing a loud bell in each Q.F. shelter, there will generally be sufficient time for detachments to be on the guns before the enemy's boats enter the illuminated area. The time it takes for a destroyer to cover the space between sentry beam and illuminated area, and the time it takes for the detachment to turn out, are easily calculated. One or two observers must, however, under any circumstances be kept on the guns. If the sentry beam fails even for a moment, the detachment must turn out and stand to their guns, and with the least trace of fog no dependence can be placed on the sentry beam giving warning. But these considerations are too varying with the locality to enable any universal hard and fast rules to be laid down. Let each district C.R.A. decide for himself what is necessary and the Inspector-General of Garrison Artillery can suggest or order any alterations he considers advisable.

Security from reverse or land attack.

The next question of construction that presents itself is that of securing protection to the battery from an attack on the land side. If the battery is sited inside one of the old pattern residential forts which we find in many fortresses, no extra protection is needed as the already existing ditch is sufficient obstacle; or again, if it is sited right in the town, in inner waters, where it is or should be practically impossible to surprise it by land. But if we find it out in the open by itself some obstacle is essential.

Ditches are very costly, and consequently we do not find them round our new works. And we appear to trust to the Government pattern fence, euphemistically called "unclimbable" but in reality easily surmounted by any man of average activity. Moreover this fence is very difficult to fire through, especially if the line of fire is at all oblique to the line of rail. A good barbed wire entanglement, about 5′ high and 8 or 10 yards deep with electric lamps, similar to the ordinary street lamp, at intervals, would prove a much more effectual protection. The lamps should not be kept alight, but only turned on by the sentries when they saw or heard anybody in the wire. Trip wires ringing an alarm bell could be placed just inside the outer edge of the entanglement to make certain of the alarm being given, but it is hardly conceivable that a single man, let alone a raiding party could get through a stiff barbed wire entanglement in the dark without giving vent to some pious ejaculation which would disturb the stilly night. A very few infantry with Magazine rifles should be suffitient for each work.

These remarks will also apply to electric light emplacements as well as to outlying batteries. A small party landed to assist a torpedo-boat raid effect their purpose just as well by knocking out the lights as by knocking out the guns. This is on the assumption that a small landing party is attempting to surprise and rush the battery by night.

Any more elaborate attack in force would be met by the infantry of the defence with the movable armament.

Permanent land defences.

The construction of land forts pure and simple, is not now contemplated. Where such works exist they will no doubt be utilized, but their cost is quite incommensurate with their modern fighting value.

Positions will of course be selected in peace time, for the infantry of the defence and for the moveable armament, covering all possible landing places in the neighbourhood of the fortresses, and all the main roads, railways and bridges leading into it; and these will naturally be strengthened by extensive use of the spade; alternative positions on an inner line would also be selected and entrenched. Possibly we may get some modified form of the South African blockhouse line; but it is fairly certain that nothing (beyond selection of position) will be done before the "emergency stage" at least, owing to expense. Moreover as these outlying land defences could not be required before the formal declaration of war, for their necessity implies a large landing, it would be sufficient to commence them during the "emergency stage," for the normal infantry garrison of any of our home fortresses is sufficient to entrench these selected positions pretty effectually in a very few hours.

CHAPTER III.

Armament.

Against raid by sea.

Still working on the assumption that we are limiting the definition of "Raid" by sea to mean an attack by torpedo craft only, the best guns in our service that we can use for the defence are the 4·7″ Q.F. and 12-pr. Q.F.

We have discarded the 3-pr. and 6-pr. Q.F. as not having sufficient bursting charge to stop a destroyer, and many men now hold that even the 12-pr. Q.F. is full light, especially when the question of armouring destroyers is seriously contemplated. One admits that unless exceptionally lucky, one or two 12-pr. shells will not stop a destroyer dead, but the generally accepted idea is that the garrison gunner of the present day can be pretty certain of sufficient 12-pr. hits on a destroyer to stop her, given a reasonable number of guns compared to the probable number of attacking boats.

The 12-pr. has the following advantages over the 4·7″ Q.F. gun, mounting, emplacement and ammunition are considerably cheaper. The detachment is smaller, and ammunition much more easily handled. Its rate of fire compared with the 4·7″ is : : 15 : 10, at least "Practice Seawards" says so.

Per contra, in weight of metal thrown per gun per minute, the 4·7″ has considerably the best of it, and the stopping power of its shell is more than double that of the 12-pr.

According to our existing classification, however, the 4·7″ is more often than otherwise not classed as an anti-torpedo craft gun; in fact where 12-prs. are also provided it is generally not so classed, and it must be borne in mind that "What's in a name?" won't apply here, as the lack of the name "anti-torpedo craft gun" means that no second relief is provided for it in the manning tables. This varying classification seems hardly right. Let us call the 12-pr. our anti-torpedo craft gun, par excellence, but in all cases where the objective is sufficiently important to tempt a big attacking flotilla, say three divisions or eighteen boats, for the sake of certainty let us have some 4·7's″ as a last resource; *not* the outer battery as we are prone to place them, but the inside battery of all; then if the outer batteries have justified their existence, the tremendous shell fire of the 4·7″ should be able to absolutely annihilate any remaining boat or boats getting abreast of them. Some people will argue that this is waste of a long range powerful gun, but if we consider a torpedo-boat raid the most probable form of attack on our coast defences, and our own Navy are the foremost to tell us this, then let us ensure that our defences are as secure against that form of attack as we can make them, and not endeavour to effect a compromise between our heavy gun defences and anti-torpedo craft defences, resulting probably in neither being efficient. It seems much more waste of a battery of 4·7's″ to site them where they *may* be able to open a long range fire against bigger ships, always supposing such an attack is ever made, and standing a good chance of getting knocked out before they have put in any useful work, than to have them in reserve, in inner waters, where the odds are heavily in favour of them saving the situation in the case of a torpedo-boat raid.

Sights. Unquestionably the auto-sight is *the* sight to use for anti-torpedo craft guns. It enables a more rapid rate of fire being maintained, but above all it does away with the heart-breaking efforts of G.G.C.'s to identify rounds from their own groups, if two or three groups are firing simultaneously at the same target.

Tide tables can be made out showing the rise or fall every half hour above mean tide level, and given the height and time of high water in the port each day (which can be found in the official blue book on tides supplied to each sub-district) the necessary correction at any hour of the day can be read off. The error of the day after some little practice can be fairly well estimated, even if one has not had trial shots in the day time at a fixed target, so that theoretically at any rate one ought to waste no time ranging. It is open to argument, however, if we have yet fully appreciated the limit of usefulness of the auto-sight. The "Garrison Artillery Drill, 1902," Vol. 2, gives ½ a minute as the probable angular error of the layer in his line of sight; this appears too small for practical purposes. Admitted that it is easy to work up this standard by day, when training layers at a fixed target in smooth water; it remains very doubtful if a layer suddenly roused from sleep will make equally good shooting at a 30 knot destroyer, which throws up a big wave even in the calmest of water, and while shells are bursting all around him. The deductions about suitable heights for the auto-sights are:—(1) Any height *h*, at which an error of X minutes in the angle of depression of the line of sight for a range R, conveys an error to the quadrant elevation of the gun within the permissible error to hit a 4 ft. vertical target, (4 ft. is taken as the drill book estimate of the freeboard of a torpedo-boat) from height (*h*) and range (*R*) will be a suitable height. (*X* being the probable error of the layer and laid down in the drill book as ½.)

(2.) And that the best shooting height is that at which the largest error can be made by the layer in the angle of depression of the line of sight at range *R*, compatible with keeping the resulting error in quadrant elevation within the limits of the permissible error to hit a 4 ft. vertical target from the height and range.

If tables showing these heights were made out and published for each nature of gun at various ranges, it would be an excellent guide to officers when selecting site for a battery. They may be known at the W.O., but it is certainly not a matter of common knowledge. There is more than one battery fitted with auto-sights in our coast defences at home which is sited too low for the auto-sight to be trusted, at the range that battery would generally be used in action.

Moveable armament for general defence.

Now to consider the armament that would be used against an enemy making a land raid. There have been great changes recently in the approved moveable armament of our coast defences, the old 20-pr. and 40-pr. R.B.L. guns that have been doing duty as "moveable armament" for years, have at last been superseded and their places taken chiefly by 4·7″ guns on travelling carriages, and 6″ B.L. howitzers, and to some stations have also been allotted some 15-pr. B.L. field guns; machine guns of rifle caliber, either on parapet mountings or infantry field carriages, have for some time past been also included.

The *rôle* of the moveable armament has not been properly realised till quite recently, and so we find that these old 20-pr. and 40-pr. R.B.L. guns were generally allotted places inside the various forts, and practically looked on as extra fixed armament.

Of course that is not right. The moveable armament should be pushed well out, to cover the feasible landing places in the neighbourhood of the fortress which are not under fire from the guns of the fixed armament, and to cover the various lines of approach from such landing places. If this argument holds good, then the 6″ B.L. howitzer is a very useful weapon for covering an otherwise undefended cove or beach. If it can pick up the range of a transport which is lying in shore to land troops, it ought to make the situation very uncomfortable. It is preferable to a gun for this purpose, as it can be withdrawn somewhat from the coast line, and is much more easily concealed.

The 4·7″ gun is not such a suitable weapon for defence against land raids. There are not many positions round our coast fortresses where the land ranges are too great for field guns, and the high muzzle velocity of the 4·7″ rather militates against its usefulness with time shrapnel. Conditions are not the same as in South Africa, where the travelling 4·7″ was first used. A raiding force will not sit down and entrench themselves and play at long range fighting. They haven't got the time. If they delay, their line of retreat, *i.e.*, their transports, may easily be cut off. They must attack vigorously if they find the defenders in position between them and their objective, and therefore long ranges can only be a matter of short duration. The 4·7″ on its travelling carriage is very heavy and moves but slowly, and then only on good roads. If an attack is rapidly pressed home the 4·7″ stands a much worse chance of retiring safely to a second position further back than an ordinary 15-pr. field gun would. Some pom-poms might be allowed for moveable armament. Admitted that their material effect was not great in the recent war, at least most R.A. officers tell us so, still their moral effect was very considerable, especially when they were first heard, and that moral effect would probably be repeated, as the Boers and our own Army are the only people who have yet have had to face pom-pom fire in action. Moreover the pom-pom is very mobile, just what is wanted in the class of fighting we should encounter.

The machine guns should chiefly be pushed out with the infantry of the defence, and only in rare cases should any be left actually confined to forts or batteries. Of course they save a certain number of infantry being locked up inside works, but nevertheless their sphere of usefulness would appear curtailed by being thus disposed.

It must be thoroughly realised that the best time to catch a landing party is when they are actually landing, and that once we permit them to land and get within rifle range of our works, even by night, they are very likely to render the situation extremely uncomfortable for our gun detachments. We only want our wire entanglements, &c., as a last resource, to prevent a rush by a small party who have evaded the picquets on the coast line; a passive defence inside the batteries is *not* the modern notion of guarding against a landing raid.

The requirements of each fortress, as far as nature and number of pieces of moveable armament, want to be thoroughly gone into by the local authorities, and their recommendations should carry considerably more weight than seems to be the case at present. Of course the first outcry against this would be "But then every General would at once ask for infinitely more guns and howitzers than the Treasury will sanction money for." That, like many another argument, requires proof. Doubtless in some places an increase would be asked for, but it is equally certain that in some other cases local opinion would tend to a reduction of the present approved armaments.

Suppose the case was submitted to the G.O.C. like this: "It is proposed to spend £10,000 on moveable armament for this fortress. Each 4·7″ gun costs £X, each 6″ B.L. howitzer £Y, each 15-pr. B.L. field gun costs £Z, and so on with pom-poms, machine guns, &c.; what are your recommendations about number and nature of pieces, and how do you propose to utilize each individual gun, howitzer, &c.?"

After a G.O.C. has made out his recommendations on this sort of basis, his ideas can be criticised at Headquarters and alternatives suggested to him, giving the reasons for differing from his proposals.

This does not seem, however, to have been the method adopted in drawing up our present allotment, and, though it may be treasonable to say so, it is not apparent to the average regimental officer on what principles the present allotment can have been arrived at.

That, if one may be permitted to say so, is one of the grave defects in our present War Office methods.

The regimental officer is kept too much in the dark over the principles that govern any change in coast defences or armament. Changes are made; the reasons are not always plain to see, and as no explanation is forthcoming, individuals are driven to build up their own theories on the subject.

No wonder then that so many different ideas on the subject of coast defence prevail amongst our senior officers, and that our junior officers have so many confused notions, collected at each station they serve in, that it is only here and there one can find a Garrison Artillery officer who has a comprehensive grasp of his profession.

Defence lights.

Though perhaps not strictly "Armament," still the defence lights are such an integral part of our defences against torpedo-boat raid that some mention must be made of them.

We want the best illuminated area that we can get, over which boats must pass to reach their objective, and our guns must be so sited as to take full advantage of this area. The lie of the coast line, and the limit of a 30° dispersed beam (the one most used by us) will fix this water area, and then we have to consider the number of beams we require for effective illumination.

Speaking generally, we have not got enough lights, nor have we a sufficient proportion of spare projectors. Our electric light trials are too often carried out under favourable weather conditions, and seldom do we get any trials sufficiently prolonged to test the average breakdowns that are bound to occur.

Over the relative merits of steam engines and oil engines, only an expert can offer an opinion, and this unfortunately the R. G. A. officer is not.

Submarine mines.
Brennan torpedo.
Submarine boats.

Though not primarily intended for use against torpedo-boat raids, there is little doubt that observation mines would be exploded were torpedo-boats discovered crossing the mine field. It is possible though not likely, that the Brennan torpedo, if installed, would also get a run against a flotilla of destroyers, but its speed is not really sufficient, and its probable effect would be *nil.*

Submarine boats may prove useful. It is impossible in their present state of development to foretell what they may do in the future. It certainly seems as if coast defence was their *rôle*, but their speed again would probably not render them very dangerous to the 30 knot destroyer.

Until they get a reliable periscope at any rate, they are not likely to prove serious foes or reliable defenders; but their moral effect is enormous (and even their detractors must admit this) so for this, if for no other reason, every defended port should have its complement of submarines.

Hydrophone.

While on this heading, just a word about the hydrophone. This is a somewhat unknown and as yet imperfectly developed instrument for recording sound waves produced by a vessel moving through the water. It has been found possible to detect a ship some two or three miles off by this instrument, but at present it is not particularly reliable. The details however are capable of improvement, and if a satisfactory instrument can be produced it ought to prove of the greatest practical value in giving warning of the approach of submarines, as well as for detecting a raiding flotilla of destroyers when a mile or two outside the sentry beam. It can be anchored at the entrance to a harbour and connected with the shore by wires along which the indications would travel, or it can be towed astern by the examination steamer and information signalled in from there.

CHAPTER IV.

Organisation.

This is certainly the most varied and difficult heading of the subject to discuss. It embraces both existing organisation in peace time, and the various changes that take place during precautionary and emergency stages, as well as the final war organisation after mobilisation is completed.

Existing peace conditions.

The "Army Corps System," as it is usually termed, is not an ideal one by any means as far as coast defence is concerned. Decentralisation in coast defence cannot well be carried out, and all correspondence in connection therewith has to go to the War Office. The number of offices *en route* entails great delay in all correspondence, and the want of local, and in some cases technical, knowledge on the part of the Headquarters Staff of the Army Corps makes their expressions of opinion carry little weight. The fault is not with the officers concerned. It is the fault of the system.

Alternative suggestion.

A peace organisation that left the whole of our coast fortresses, with their entire *personnel*, outside the Army Corps scheme entirely should not be hard to devise. Each fortress should have its Fortress Commander in peace time with his staff (or perhaps a somewhat modified staff) the same as required in war time. On all points the Fortress Commander should correspond direct with the War Office, with no intermediate channels. The infantry garrison allotted should be the number of men considered necessary during the precautionary or emergency stages. The existing Garrison Regiments recently formed could probably be considerably increased, and these are the class of men who should form the infantry peace garrison. If more battalions of the Garrison Regiment could not be formed, then infantry battalions last home from foreign service should be allotted, and these should not form part of any Army Corps. Reliefs would be carried out as now provided for, viz., if say four battalions of the 1st Army Corps have to proceed abroad in the ordinary course of reliefs, their places are taken by four from the 2d Army Corps, these again filled from the 3d Army Corps, the four coast defence battalions that had been longest home would then join the latter Army Corps, and the four battalions that were relieved abroad would become coast defence battalions.

By this plan the organisation of a coast fortress cannot become suddenly dislocated by rumours of war, and not by actual war itself until at least three Army Corps have left the country.

What would happen at this moment, were we threatened with a European War, would be that the existing infantry garrisons of all our coast fortresses in the south of England would be required by the Fortress Commander during the precautionary and emergency stages, and probably be working under his orders at very high pressure, while the G.O.C. 2d Army Corps, to which these infantry units all belong, would be simultaneously endeavouring to equip and concentrate his command; in fact two men trying to command the same unit at the same time, and having definite and opposite views concerning its disposition.

If the infantry garrisons of coast fortresses were constituted as suggested, there would be a good nucleus of officers and men with local knowledge, an enormously important factor, when Militia were embodied and joined their moblization stations.

However, there is little probability that these suggestions will ever see the light of publicity, and still less that they will ever be seriously considered by those in whose power it is to carry them out. Let us then turn to the more detailed points, which are after all unaffected by the question of whether units of the 2d Army Corps form the peace garrison of Portsmouth or Plymouth, or whether they don't.

Defence schemes.

The defence scheme of a fortress contains, or should contain, the whole system of organisation, both of *personnel*, and *matériel*. Unfortunately it must be admitted defence schemes are not kept up to date, nor do they go into sufficient detail in the case of units which are not quartered in the fortress in peace time.

The "Instructions for preparation of defence schemes," issued in June, 1901, are admirable, but they do not seemed to be acted on as a rule. In most places, the duty of Secretary of the Defence Committee devolves on some Staff Officer who has already as much work as he can conveniently perform, and there is no incentive to him to work hard at the defence scheme as well. The Local Defence Committee frequently exists in name only, and at times not even in name. Many important W.O. letters intimately connected with questions of general defence never find their way to the Secretary of the Defence Scheme at all, being dealt with by A.A.G., C.R.A., C.R.E., or other Staff Officer immediately concerned, and filed in the Central Registry eventually.

It is suggested that the defence scheme for each fortress or defended port be kept absolutely separate from the rest of the defence scheme of the district in which it lies, and that there should be a secretary of each fortress defence scheme, who should invariably be an officer who serves on the staff of the Fortress Commander on mobilization; if possible, the man who in peace time is Staff officer to the man who becomes Fortress Commander in war time.

The W.O. treat defence schemes as such secret documents that the individuals most concerned get such meagre extracts from them, as to render the scheme comparatively worthless. The general idea, and really the greater part of the detail, ought to be known by every officer in the fortress. It can be kept confidential enough, even if this was done. This enormous secrecy, of what a foreigner probably knows in every detail, is responsible for cramping the intelligence and initiative of junior regimental officers. If some keen, or merely inquisitive, Subaltern begins to ask conundrums about general defence, he is somehow choked off, and given to understand that such things don't concern him, and that he had better go and study his gun drill instead. What is the result? The average Subaltern is quite content to accept the situation, and consequently remains in ignorance of the broad principles of coast defence, or of their application to the particular fortress where he is quartered, and his mind does not soar higher than considerations of whether No. 2 should handle a sponge with "right hand back under" or the reverse! Possibly this is a slight exaggeration, but it must be confessed it is not far wrong. Probably this state of affairs is not fully realised by those in high places, but let the question be suddenly put to any young R.G.A. Subaltern "What is *your* place on mobilization?" and in nine cases ont of ten he won't be able to give a definite answer. He may know what fort he goes to, its long odds he doesn't know what group.

Go a little further and ask him if he happens to be orderly officer some afternoon, and in the absence of any senior officer in barracks, he opens a telegram saying "Precautionary stage exists," or words to that effect, what steps would he take, its very long odds that the boy would be hopelessly at sea and his probable answer would be "send for the Sergeant-Major." This state of "Organisation" is hopeless. Every company officer *must* know every detail connected with the allotment of his unit on the commencement of the precautionary stage, and should be constantly questioned on every point connected therewith. He may find himself in a detached work, away from his Major and the rest of his company. He should know accurately how and where every man of his gun detachments is to be quartered, where they draw their rations from, where their water supply is, through what channels he gets his orders or information; in short he should be able to parade and move off with his own group details without a single further word of explanation or instruction. And the great advantage of *this* suggestion is that it can be fully carried out without costing the taxpayer a halfpenny! Would that all improvements could be effected as cheaply.

Equipping of light Q.F. shelters.

To enable all anti-torpedo-boat batteries to be suddenly manned, if required, with the minimum amount of confusion, it is suggested that every shelter in light Q.F. batteries should be fully equipped in peace time with all that men would require for immediate occupation, such as blankets, watch-coats and oilskins for the look-out men, cooking utensils, &c. Hammocks are now provided and kept in these shelters, but nothing is more unsuitable. They are not by any means easy to get out of quickly, and the time it would take for the entire group detail to turn out would be, at a moderate computation, three times what they would take if they were on the floor, on bed boards, or in the ordinary barrack bedsteads. It is urged in their defence that hammocks take up much less space. This is open to argument. The ordinary Q.F. shelter is designed to give each occupant about 300 cubic feet of air space, or half barrack synopsis. As they are generally fairly low, say 7'6" or 8", this would work out about 40 square feet of floor per man, leaving ample room to fit in beds or bed boards for the full number of occupants.

Sources of information and communications.

There have been great strides made in the last few years in the way of establishing war signal stations along the coast, which forward information about passing vessels to various places; speaking generally to the Head Naval Intelligence Office of the group, to the war signal stations each side of themselves, and in some cases to a specified military officer as well. The detail is all shown in a "secret" blue book on the Distribution of Intelligence issued by the Admiralty. These war signal stations are found entirely by the Royal Navy. There is one grave defect, however, in the system, and yet it would not be difficult to remedy. These signal stations are not all connected by special telegraph or telephone wires, and in some places a message has to be taken a mile or two away to the nearest village post office and transmitted by ordinary G.P.O. wire to its several destinations. This is inexcusable. If intelligence is to be of any value, it is essential that it should be distributed quickly.

As an instance of this, the following is what actually occurred several times during the Naval Manœuvres of 1901 at one of our home coast fortresses. A little bundle of telegrams would be delivered to the Fortress Commander from the local Post Office, at say, 8 p.m., and on being opened would be found to come from three war signal stations (one as far as 40 miles away) giving information about passing ships, in some cases four hours after the ship in question had passed the examination line.

Marconi. The value of wireless telegraphy to coast defence cannot be exaggerated. Nearly all our port war signal stations are fitted with Marconi appliances, but the system might be even further extended,and have every war signal station thus equipped—of course it would cost money to install and keep up the *personnel*, but on the day that a naval war broke out we would be only too thankful to find the system working all around our shores.

Internal communications. The internal telephonic communications at the present day in our coast fortresses have been very carefully considered, and in the main leave nothing to be desired. The only suggested improvement is one which exists in certain places, but which has not been universally installed, viz., a continuous alarm circuit ringing up all Light Q.F. batteries simultaneously, and emanating from the look-out post or posts established at the sentry beam or elsewhere. It is not essential to have a telephone instrument on this line, in fact it is better not to have. All that is required is a heavy electric bell in each battery, and when it is heard, the gun detachments know they must stand by.

The typewriting telegraph mentioned in Captain Spender's article in R.A.I. "Proceedings," Vol. XXIX, No. 7, 8, and 9, sounds very satisfactory, and if it is all that he claims for it, the sooner the system is introduced the better. Telephones are apt to go wrong, at least R.A. command lines do very frequently, and the other system seems preferable. Why some order dials are not introduced into our fortresses, goodness only knows. Not the old pattern that we experimented with ten years ago, but those made by Barr and Stroud. Sufficient orders could probably be marked on them to cover all contingencies during action, just the time when orders must go quickly, and when telephones are sure to fail us.

Examination service. The examination service perhaps hardly comes into the question of raids, and yet it would be advisable to make some reference to it. The existing regulations are somewhat cumbrous, and yet it is hard to say how they can be modified. Except that by employment of picquet and patrol boats, working some little distance further out than the actual examination steamer, we ought to be able to determine in most cases whether a vessel is hostile or not, before she is at such close quarters as the actual examination line.

Training of Militia and Volunteer Artillery, with the guns of the moveable armament. Perhaps no point of our existing organisation is so weak as this one. It all results from the fact already expressed that the *rôle* of movable armament has not been properly understood, and that the *matériel* supplied, until quite recently, has been of such an antiquated nature, that it would have taken a keener soldier than has yet been found to attempt a serious training with it. It must be remembered that in none of our home coast fortresses are men of the R.G.A. told off for moveable armament, simply because there are none available. The R.G.A. are allotted first to the light Q.F. guns of the fixed defences, and if there are any men left after this, to the most important of the primary armament.

Consequently moveable armament always has been and probably always will be in the hands of the Auxiliary Artillery, be they Militia or Volunteers. For the proper training of such Corps as are thus allotted, it stands to reason that an Adjutant and permanent staff, who are familiar with the uses of Artillery in the field, are essential.

This does not imply that these officers and N.C.O.'s should have belonged necessarily to Siege Train Companies of the R.G.A. That is one of the points frequently missed by even gunner officers. A battery of Heavy Artillery with 4·7″ guns or 5″ or 6″ howitzers is *not* the same as a Siege Train Company. The error crept in in South Africa, by sending out a Siege Train Company (No. 15, Western it was then), with 4·7″ guns. A Siege Train Company is a unit intended as its name implies, for taking part in the attack of a land fortress, and its training does not necessarily cover the principles of employment of Heavy Artillery in the field.

Probably officers and N.C.O.'s of the R.F.A. after they had learnt the actual drill of the heavier gun and howitzer would be more suitable than the R.G.A. officer or N.C.O. Land ranges are not always available at our coast fortresses, and it may be necessary to train a unit at some place like Lydd, or wherever it is decided to establish the Lydd of the future.

A thorough knowledge of the country in the vicinity of the fortress is essential for all ranks, and especially of the positions selected in the defence scheme to be occupied in the event of attacks from various points in the neighbourhood.

A certain amount of practice over sea ranges should be carried out by howitzers from the actual positions that they would occupy covering possible landing places.

Infantry Militia.

If found practicable, all Infantry Militia Regiments should also train frequently at their mobilization station. There may be greater difficulties about this than a gunner officer can anticipate, but at any rate it should not be hard to get the C.O., his second in command, Adjutant and Quartermaster, with a good proportion of Captains of Companies, to attend every year at their mobilization stations for a few days, and given every opportunity of making themselves thoroughly acquainted with all local conditions.

Conclusion.

In conclusion, one must make one or two general remarks, about the Artillery *personnel.* We want more companies of R.G.A. at home. There are at the present moment 37 companies of R.G.A. at home and 68 abroad.

By the present system of finding drafts for foreign companies entirely from home companies, each of the latter has to feed about two foreign companies. Consequently, a company of R.G.A. at home is largely composed of recruits, and as men are trained they have to be drafted abroad. While this state of affairs exist, we can ***never*** be efficient at home. There is sufficient outcry already about the linked battalion system in the infantry. What would it be if each home battalion were asked to feed two battalions abroad, and not one?

Of course it is urged that we have ample Militia and Volunteer Artillery to complete our home garrisons on mobilization. So we have in point of numbers, but their training is wholly inadequate.

The nation is either ignorant of, or else deliberately shutting its eyes to this very vital question. Doubtless it is again a question £ s. d., but when it comes to be a matter of fighting for our national existence in a European war, the statesman who has cramped our R.G.A. *personnel* will have a grave responsibility on his shoulders.

We have heard a good deal of debate on the Army generally, in the last few weeks, but never a word on the subject of coast defence. Why? Because nobody seems to know anything about it, or to realize its national importance.

Let us hope somebody will be found with knowledge enough and weight enough to voice its cause, before we see a foreign fleet off Spithead or up the Hamoaze. If not, there will be a worse day for England than she has yet seen.

It won't take an impossible number of men, it won't take such an enormous sum of money, but it will require a first-class organiser, with a thorough grasp of all our requirements, and all our existing shortcomings, to bring our coast defences to that state of perfection which will be found to be essential, in case of war with a first-class naval power.

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The Defence of Harbours against Torpedo-boat attack.

BY

FRED T. JANE, ESQ.

(A Lecture delivered at the Royal Artillery Institution, Woolwich, Thursday, 12th November, 1903.)

MAJOR-GENERAL F. G. SLADE, C.B., R.A.,

Inspector-General of Royal Garrison Artillery, *in the Chair*.

The CHAIRMAN:—Ladies and gentlemen, I am sure it is quite unnecessary for me to introduce to you the lecturer this evening. Several of us have had the pleasure of sitting under his spell, and I am sure all of us are familiar with his book which has been a very great help to the defenders of our coasts, and I will now ask him to favour us with his lecture.

The LECTURER:—Mr. Chairman, ladies and gentlemen, in venturing to address you upon this subject of defence against torpedo craft, I would desire at the outset to call your attention to the general obscurity that exists on the question. By this I mean not only the absence of data, but the absence of any, what I may call, "sealed pattern plan of defence."

I do not see how we could have one as things are, for we have very little to go on. The most that we can go on in the way of facts we may take from the Chino-Japanese War, which even if its results could be accepted as conclusive then, may be nullified now by the subsequent advent of the destroyer. However, let us first review the Chino-Japanese operations at Wei-hai-Wei.

There were altogether four attacks upon Wei-hai-Wei, and the defence consisted of three 1″ or 1½″ iron steel hawsers with wooden floats every ten yards and a boom of this sort was placed at each entrance, but both booms had openings in them. The eastern entrance had two openings, there being one torpedo-boat one inshore protected by the forts that fell into the hands of the Japanese, and a larger one in the centre for big ships which was protected by mines, which the Japanese attempted to destroy, but only partially succeeded in doing. The forts guarding this entrance were already in the hands of the Japanese, and therefore from the gunners' point of view Wei-hai-Wei can hardly be regarded as any criterion whatever.

The points of interest about the attack worth noting are, that in the first attack of all, which was made on the 1st of February, when the Japanese boats came in they were sighted by the forts held by Japanese soldiers and fired at under the impression that they were Chinese boats. The boats then retreated untouched.

The second attack, which was made on the 2d of February, was again a failure, as the Chinese sighted the boats as they were coming into harbour. They again retired at once.

Then for the third attempt the scheme of attack was varied. A feint was made on one entrance by six boats, and the eastern entrance was attacked by twelve boats. It was an intensely cold night, there was no moon, it was about 3 o'clock in the morning. The Japanese lost two boats and one or two were very much damaged. Only one was hit by a 3-pr. The forts did nothing. In fact the Chinese forts, so far as could be ascertained, did not see the boats until they were more or less amongst the big ships.

On the 4th, there was another attack, which was a complete surprise, in which they lost two boats from ship fire. So that practically we have really very little to go on, so far as torpedo-boat operations in a time of war are concerned.

All we may deduce I think from the Chino-Japanese affair is that the rule with the boats seems to have been, if once sighted and fired on, to retire at once and leave everything to the chance of getting in unseen on another occasion.

Of course if this is to be the rule, defence will be a very easy thing, because a sharp look-out and a gun or two will be all that will be required. But we have to bear in mind the sort of attack, or what is likely to be the attack on us, may not be on similar lines to that which the Chinese met. I do not think we can assume that it would be the same. The Japanese were short of torpedo-boats and they could not afford to throw away what they had. Now-a-days torpedo-boats have increased very rapidly and destroyers have multiplied exceedingly, and I think we should take it for granted that if any attack is made, it will be pushed home as long as a single boat is left. Therefore the problem with regard to defence is to account for every single boat that attacks. Say, for instance, that twelve boats attack, it will not be much good accounting for eleven if one gets through.

There might be attacks made upon us the first night of a war when the enemy would hope to find things unarranged for, and later on when attack was unsuspected because of long immunity. It is of course extremely improbable that we should have a blockaded fleet, but we should very likely have one or two injured ships. Attack is pretty sure to be pressed home as torpedo-boats are so much more plentiful now and a few can easily be spent on an off chance.

The first question in relation to defence it seems to me is to find out what has got to be defended, whether the boats are coming with a view to securing any odd ship, damaged or otherwise, that may be in a harbour or whether their intention is to try to block up the docks and dock entrances by getting inside and torpedoing these. The latter perhaps is what we might be most in fear of and must expect to see attempted.

Then if we take the various defence systems, every system seems to have its advantages and disadvantages. If we take the favorite system, No. 1 gun firing at No. 1 boat, No. 2 gun firing at No. 2 boat and so on, that in theory may be a very excellent system, but the defect of it is that in practice, No. 1 boat becomes No. 3 perhaps at one moment and No. 2 at another, and there is always the danger that No. 1 gun may be firing at No. 2 boat, and No. 2 gun at it also, leaving one boat neglected, and a practice of rushing based on the chances given by this system exists, and, if one of a dozen gets through, untold mischief may be done.

There is also of course the question of what is to happen if more boats than guns should be used.

Then take the zone system. There success depends upon doing a great deal with comparatively small armaments. If the boats, knowing that the zone system is going to be employed, come in in bunches, then again there seems to be a very good chance of one boat managing to crawl through. If the boats would each enter each zone singly, their fates would be certain; but we cannot depend on that happening. Obviously the gun that has only one boat to fire at and the gun that has a dozen in its zone are very differently situated. Still, I incline to fancy that the zone system is better than any other. But whatever system of defence is adopted, there is always grave danger in a lack of definite co-operation between the Army and the Navy, and I think there can be no doubt that if the two forces fail to act in concert, it would tend to help and assist any attacking boats more than anything else.

As things are at present, we may assume, I think, that the shore defence would be entirely in the hands of the Army, but the Navy will, by having ships in the harbour, also be conducting some defence of its own.

This defence will perhaps include picket boats and if the attacking boats realize, as they very likely will do, that there is a picket boat defence, they may manage to take advantage of it, and either our picket boats may get destroyed under the impression that they are a hostile craft or the hostile craft may slip through as picket boats; but the subject of picket boat defence I shall allude to later on.

Next to gun fire, perhaps, search-lights form the most important part in all defence operations. The value of search-lights is I think a very debatable point. From my own experience on board torpedo-boats and destroyers rushing harbours, I think there is a great deal to be said both for and against the search-light. Of course for rushing in in peace time you are not firing any shotted guns, and therefore you cannot have any data to go on, as to how easy or difficult it may be for a destroyer coming in to fire at a search-light and perhaps pick it out, and then in the sudden gloom get in easily.

Some experiments in Germany seem to have shown that it is not a difficult thing to hit the search-light. My own impression of search-lights is that when you are three or four miles out, they do not show you up, but they do show the way in, and show it tremendously clearly. This is perhaps more true of fixed beams than of searching ones; the difficulty to the attack comes in where the searching beam gets full on the boat, inasmuch as then the boat can see next to nothing, and when the light goes away or is evaded there is a sort of complete blindness; I think that the value of the search-light for defence is perhaps to flash it on to the eyes of the boat's crew and then off again. Its use thus should lead very often to the boat going ashore or running into other boats from the temporary blindness that the flash has caused.

The search-lights no doubt light the way in to some extent, so much so perhaps that the real value of them to defence is only the confusing effect they have on the attack. If the boats does evade the search ray it seems to me that it is not very likely to be picked up again, whereas if a deliberate flash system be adopted, there will be no need to bother about picking up. I am not sure that a good deal could not be done by a mechanically operated light. Exact experiments can hardly be carried out because of the danger involved in a really practical demonstration; but I may mention one walk in life in which a somewhat similar system is carried out tolerably scientifically and methodically. The ordinary policeman is often an adept in taking advantage of the impotence to which an assailant can be reduced by judiciously alternated light and darkness. I certainly think that something valuable might be evolved by regarding the searchlight as a weapon rather than as a substitute for daylight—its usual use.

In harbour attack I notice a boat has great difficulty in evading the search beams at all, but at sea I have certainly noticed that the boats manage to evade the beams very well, and I think that in war time a boat coming into harbour and trying to manœuvre in order to evade the light would be manœuvring differently to what it is in peace time; when the officers in command of the attacking boats do not care to run any unnecessary risk which is not warranted. But in war time where the question of retreat and attack comes in, I think a boat dodging about might possibly get out of the range of the searching beams and not be picked up again. In that case the searching beams would be to your disadvantage; but the great point altogether about the search-lights is that it seems very little thought has been devoted to the question of fighting search-lights with return lights. It was tried the other day at Portland when destroyers slipped in, and as soon as they were sighted switched their lighs on to the forts and opened a heavy rifle fire on the men at the guns, and it is an interesting question as to what would happen in war time. This more or less unexpected rifle fire, coupled with the glare of the attack's searchlights, must have a very disorganizing effect on the defence for several minutes, say, for long enough to allow a certain proportion of the boats to slip through unhurt or nearly so.

The question that requires an answer is, how that sort of thing is to be met? Everything depends as I said before upon the point—which is of more importance than anything else—that nothing must be allowed to get through. How to stop the boat getting through therefore becomes a doubly important problem. It is not so much that the boat has to be sunk, but it has got to be stopped from doing any mischief before it goes under.

Supposing a modern destroyer was hit by one 12-pr. shell, it is extremely improbable that that 12-pr. shell would sink her.

Then we will say that a foreign destroyer is attacking Portsmouth; supposing she gets up by Clarence Pier and she gets a 12-pr. shell into her, will that boat stop there or will she drift right on up harbour where she could ease off her torpedoes before she settled down for good.

That is why I think the Maxims might be an extremely useful adjunct to the defence, both alongside the 12-prs. in the batteries and also where they are never put at all, that is at the entrance to the docks; so that supposing the boat is coming up, a Maxim fire can be directed on her sufficient to kill anybody at the tubes. The danger from the boat lies entirely with the men at her torpedo tubes, and to destroy the *personnel* in that case would be as good as destroying the boat.

Then the question with regard to booms is a very vexed one indeed. I believe the theory in the Navy is that the Navy can always jump the most ideal of booms; but in British harbours at any rate we cannot have those, for we must have ways for getting in fairly quickly and ways for getting out fairly quickly. This means entrances, and supposing these entrances to be only opened to let ships in or out, there is always the chance of an attack being made about that time.

We may assume that, supposing an attack to be made at all, one will very likely be made immediately war is declared or possibly a little before. The scouts which in the ordinary way might be lying off a harbour may not be out then, or they may be evaded. The theory animating the boats, certainly the one that animates the French torpedo flotillas, is that if they can only make their attack sufficiently early in the war they will come in at the time when everything is not quite ready—when perhaps the men are not all told off to their stations, and that they will get their chance to look in then, but quite as likely attacks might be expected several days after the war had commenced, when the first vigilance of the defenders had begun to slacken, especially in the early hours of the morning.

Supposing the booms to be an adjunct with a mine-field, the Chinese at Wei-hai-Wei had some mines, and it was reported on one occasion that some of these were exploded as the boats were passing, but the Japanese say that no damage whatever was sustained by them, and they rather had a theory that the mine would probably not hurt such a little thing as a boat rushing in. But whatever kind of mine is adopted, it may be taken for granted, I suppose, that the enemy will try and countermine, and if they countermine then it appears to me that there will be very great danger of the defence's attention being distracted by this countermining and possibly a certain amount of firing in that direction will be carried on by the enemy to secure a chance to make a second attack from some other point and so slip in.

Therefore perhaps the question might be gone into more than it is as to whether mines are or are not to be regarded as part of a harbour defence against torpedo craft, and, if so, whether a special kind of mine might not be served out to harbours intended solely to meet torpedo-boat attack. On the whole I fancy that the danger of distraction that countermining operations may afford, will render the mine defence a curse rather than a blessing to the defenders.

The submarine boat presents as grave a danger perhaps as any other form of attack. We are just beginning now to worry ourselves about submarine boat attack, and the question is how is it to be met? It will presumably have to be met by booms with nets below the surface in conjunction with a series of mines, but it is a very difficult problem. The gun is no good against submarines. The boat cannot very well be shot from the shore by any existing gun. The odds against hitting it are tremendous, even if it be awash; if it is coming in submerged, it is about a million to one that the periscope will not be hit; and even were it hit, the boat would still exist. It can still pop up and then disappear again. The first question that arises with regards to the best defence of a harbour against submarines is that it will probably need an exceedingly good and skilful commander to take a torpedo-boat up any harbour that we have. A thorough knowledge of the tides would hardly be his, the knowledge of the currents would not be his, and although he might possibly be able to do it in peace time, in war time, in the case of a submarine attacking a strange harbour under fire, we may, I think, rest assured that the probability is that it would get flurried. We might also be able to secure a boom with torpedo nets down below in which the boat would get caught up. But unless there is a certain amount of flurry and risk to the boat, I do not see what is to prevent the boat being armed with appliances to cut through the boom.

Or we might let the boat go cheerfully up inside the harbour and deal with it there. That would necessitate the employment of picket boats with spar torpedoes, but the spar attack against submarines does not seem to be altogether so successful as newspaper accounts make out. The submarines seem to be rather a difficult thing to stop in that way.

This question of submarine attack stands to be the problem of the future. What is to be done? Whatever device is thought of, anybody who has to do with submarines will waive it aside and say, "Oh, but submarines will get in." But even if we refuse to admit that to-day, although the submarine of to-day may be a defective weapon, the submarine of the early future will possibly be something very different indeed, and I do not see what we are going to do with the means for defence available at present.

I think this is a problem that will probably have to be left to the Navy to solve—this defence against submarine boats coming in. But as they would be more likely to attack the harbours with fleets in them than not, they would come under the Navy's province as things are at present.

That brings us back again to the old problem of divided control. My own theory is that the ideal arrangement would be that harbours should be absolutely defended by the Army or by the Navy, by one and not by the other, and in view of the fact that the Navy out at sea will be put to a tremendous strain in guarding against torpedo attack, the strain for instance of steaming full speed, and possibly the strain of battle, it appears to me to be exceedingly necessary that the Army should be able to guarantee absolute peace to it when coming into port. But the Army certainly is not likely to be able to guarantee that absolute peace if the Navy is carrying out one scheme on the water and the Army carrying out another ashore. If everything is left to the soldiers in regard to defence, then booms, mines and so on are much less likely to be sources of, I will not say disagreement, but of misunderstanding than as things are now.

I believe it is generally understood that if we go to war, there is likely to be a good deal of misunderstanding about mine fields, and I think that if the water inside a port or a harbour instead of belonging to the Navy belongs to the Army, we should be better able to guard against troubles of that sort. The alternative would be, supposing this Army control to be objected to, to have a certain number of harbours like Portland in which the defence was entirely left to the ships inside it, and bases like Portsmouth which would not have fleets lying in them, but docks and things of that sort to be defended, should be left entirely to the Army to control and defend.

This would of course necessitate to a greater degree even than at present the study of each individual harbour, a knowledge of all its currents, its tides and shoals, all of which is best picked up by boating. I believe that there is a very good knowledge of most of our harbours on the part of many of the officers of the Garrison gunners which they have acquired by boating and they seem to be thoroughly acquainted with every shoal. In case of attack by hostile torpedo craft this knowledge should be invaluable to them, because they would know better then where to expect attack and be better prepared to meet it.

The second point would be to learn thoroughly the draughts of all probable enemies. Of course where there are we will say a hundred boats all drawing under 10 feet of water, it is not very much satisfaction to know that if twelve boats are attacked they are some of the hundred. But there are always a certain number of largish boats which cannot attack certain harbours. If all the draughts were known and studied, then the attacking force would be known or guessed at before it was properly seen and the defence could be conducted more satisfactorily.

Then I think it would be very necessary to study carefully what damage the enemy can do inside a harbour and guard against it. Say for instance what damage could an enemy do inside Portsmouth? He might run in perhaps at the western entrance or he might run in at the eastern, but supposing him to succeed in evading the guns there, and to get inside and come up the channel into the harbour where there is a very nasty twist, any hits in the steering gear of any boats coming up there would be extremely useful to the defence; but we might have another sort of harbour where the hitting of the steering gear would not be of any use whatever. Then supposing them to pass the Blockhouse at Portsmouth and to get inside the narrow part, what is to be done to them there, and who is to look after them if they do get there?

I have not heard myself who is to look after a foreign boat which does get inside Portsmouth harbour, whether it is to be left to the ships that may or may not happen to be lying there, or whether guns would be specially told off for the purpose. But certainly I do not think, from what foreign officers with whom I have conversed upon the subject say, that we have provided all the defence we might for a boat that does manage to get past and so get loose in the harbour. The boat would not reckon on coming out again, it would have done its work five minutes after it had got inside. The question is what is to be done with that boat when it is inside? The principal object of the defence when attack is being made, and when the boats are coming in, will be I take it, not so much to sink the boat as to stop her doing mischief. Sinking her of course is the surest way of dealing with her, but owing to the difficulty of sinking her at once it may be advisable to have a supplementary defence, and that is the reason I suggested the Maxims and Nordenfeldts. Suppose a new sort of Nordenfeldt, set up on end, and firing across a zone. If a boat were coming, say, within a range it may be of 50 or 100 or 150 yards, and the Nordenfeldt were put the wrong way up as it were, one barrel would hit at 50 yards, one at 100 and the other at 150; and I think that if a gun of that sort were invented it would be rather an ideal weapon for the defence of harbours, and if several of these guns were placed at intervals which would make zones of fire through which every boat would be compelled to pass, a great advantage to the defence must be effected. The guns on beyond would then be able to deal with anything that got through the zone of this fire, but the zone of fire from Nordenfeldt bullets and Maxim's on a destroyer or torpedo-boat, would be a very serious thing indeed. Supposing a Nordenfeldt bullet to get inside the engine room, it would do as much harm as a 12-pr. A 12-pr. of course would blow things about a great deal more but the boat would still have her way on her.

Now supposing her, instead of that one 12-pr. to be hit by ten or twenty Nordenfeldt bullets distributed about in various parts, of course we may ask ourselves which is going to do the more harm. We know she will ultimately sink from the effect of the 12-pr. hit, but what will she do before she sinks? Supposing one or two bullets to get into the engines, the question is whether the total result of those or the accumulation of those may not be much more serious against the boat than the one put from the larger piece?

The new British cruisers appear to be armed on an idea not altogether different to this. As I understand the latest cruisers are not to be fitted with the 12-pr. but with a larger number of 3-prs. on the principle of getting more hits with less individual damage for isolated shots.

I think this matter of naval ingenuity should always be very carefully studied. Naval men are remarkably ingenious, and although the torpedo attacks we get, occuring as they do in time of peace, do not show it to the full, yet I think in time of war we should fully realize the great advantage that would accrue from a study of this very important branch of the subject of defence.

The case that I quoted of an attack on Portland where the boats stole up and when they were sighted, switched on their search-lights and then opened a heavy fire—that is the sort of thing that should be very much thought out I think, and we should ask ourselves what other little devices are there of that sort that boats might employ?

I think we might find our ideal defence if the gunners were all sent out in the torpedo-boats and destroyers and the naval men were put in the forts. The gunners out in the boats would know all the weak points of the forts and the boats would be manœuvred to come in in the best way against the forts, and that would furnish valuable data afterwards to know from what point the greatest danger might be expected, whereas the method in which the naval men conducted operations against the boats would possibly give a few valuable wrinkles that had not been thought of before. Naval men would naturally best understand what would be likely to damage boats very considerably.

I do not think that this kind of thing is likely to come about, but there have been steps in that direction, which I think everbyody should be extremely glad to see. Lately Garrison gunners have been out in torpedo-boats watching the attack, and from all I hear I think that seeing the thing from the other point of view has been of very great assistance indeed to those who will have to defend our harbours in war time. Being in a boat slipping in, and realizing the joy of slipping in which exists in the torpedo-boat, should enable the gunner to realize very fully indeed not only the ease or difficulty, as the case might be, of the slipping in; but the meaning of what a single boat out of a dozen slipping past would be.

It might be well to add that a combined attack is a thing that might very possibly happen; that is to say an attack we will say of 12 torpedo-boats or destroyers, supported by one or two cruisers, seizing a favorable moment. We will assume, for the sake of argument, that a British fleet is in the channel and that it goes in chase of a foreign fleet, and we will assume that this British and foreign fleet are in touch, the cruisers of either side operating together, cruising and scouting together, that is the time at which one or two cruisers attached to the hostile fleet might be detached in order to make a rush on a place like Portsmouth, where if the channel could be blocked up or the docks destroyed, incalculable mischief would result. If the torpedo attack were supported by cruisers, (of course we could not be sure that it would be—we may hope it would not be—

but we cannot fail to recognize that such a thing is possible) and the cruisers came in and opened a heavy fire, under cover of which the boats could rush in, I think we should have an ideal attack from the attacking point of view. It is one which will be more dangerous than anything else, this attack of ships coming in unexpectedly with the object of creating a diversion, sending shells higgledy-piggledy about and round the forts, and then under the cover of the smoke and confusion torpedo-boats rushing in all of a heap, in the hope that one boat will get through, never mind what becomes of the rest. That, I think, is the form of attack that we must especially prepare for. In it there will always be danger; while any other form of attack will probably be doomed to failure. (Applause.)

DISCUSSION.

The CHAIRMAN:—I will now ask Admiral May if he will open the discussion with any remarks he may wish to make upon the lecture.

Rear-Admiral H. J. MAY, C.B.:—General Slade, ladies and gentlemen. The point which, as a naval officer, I consider most worthy of discussion, is the general condition of an attack by torpedo-boats on a ship or ships in harbour.

We consider that when an attack is made on a ship or squadron at sea the odds are fairly balanced with regard to the chance of the boats succeeding, but immediately the ship gets into harbour the pendulum swings very greatly against the boats. First it is not easy to find a ship in harbour, she may get away into some corner where it is very difficult to see her, again she can get her nets out, she can have the shelter of a boom, and finally there are the garrison gunners on shore who will attack the boats as they come in. So that I do not think that the ordinary above-water boat is such a dangerous opponent to a ship in a fortified harbour as many people imagine, nor do I quite agree with what has been said on the question with reference to the dock gate. The dock gate is a very small thing, and it is a very easy matter to rig a raft or small boom with nets across the dock gate, when an attacking boat would find it a very difficult thing to get even its money's worth for the torpedoes fired out of an attempt made against a cassion thus protected. But conditions are changing; we have heard a little about submarine boats to-night, and we shall hear more in the future. Of one thing I am sure, that the above-water boat, with her big engines and her great vulnerability to guns, is not at all the best boat to use for the purpose of conducting an attack upon a ship at anchor where speed is not of great moment. The low speed of the submarine class of boat, which handicaps her at sea, is quite sufficient for carrying out an attack in harbour. But the submarine cannot be dealt with by guns from the shore. She must be met afloat, and that seems to me to be the pressing problem that has to be solved at the present time.

A year or two ago it was true that owing to the deadly fire of Q.F. guns it was quite unnecessary to have any guard boats afloat. But that day is gone, and under present day conditions with which our gunners have to deal, the defence will have to be much more afloat than it has been, and consequently there will have to be better co-operation between the Navy and the Army.

We have many instances in history of combined operations being carried on just on the edge of the shore. Those operations were usually successful when the Navy and the Army worked together harmoniously, but otherwise there was confusion and failure. When boats are used it is essential that the garrison gunners should be familiar with the officers in the boats and that the naval officers should frequently go ashore to the batteries. There must also be complete harmony between the commanding officers, and then things will go well. It may be that changes in organisation are desirable to promote the working in unison of the two services, but what we have got to see to at the present time is, when we are fighting together on the edge of the water, some being on shore and some afloat, that whatever we call ourselves, being all the King's officers, we must work together harmoniously.

With regard to the question of the guns on shore for opposing boats. The 12-pr. does not altogether commend itself to me as the most satisfactory defence weapon. A gun is wanted that will quickly stop a boat, and for this purpose a high explosive shell is the best projectile. But the 12-pr. cannot fire lyddite. An ordinary powder shell hitting a boat high up, passing through the funnel or upper works will do no harm at all. But a lyddite shell detonating on funnel or venilator, will stop the boat. The cruisers mentioned by Mr. Jane have 6-inch guns as well as 3-prs. and it is the former gun that is most deadly. The 4·7″ gun is a very good gun, and though such guns are big and expensive, there is much in their favour, especially when combined with 3-prs. or Maxims for attacking the exposed officers and men on deck. As long as people in the torpedo craft know they are going to be fired at by good sized shell, they will very wisely keep as high up as possible clear of anything that will make splinters. Those men can all be knocked out by a Maxim. The only drawback that I know of about the Maxim is that the Maixm makes a tremendous glare at nights; it gives one continuous glare of flashes; so that I think the ideal gun is the smallest gun that can fire a high explosive shell, supplemented by something in the Maxim way that will put a lot of bullets on to the deck of a craft in a very short time. And finally there is the counter attack to be considered.

I can hardly conceive that if you have a considerable naval force in harbour, they will tamely remain on the defensive doing nothing. All history tells us that what the enemy fear most when they approach a British harbour is not the excellent guns on shore and the excellent gunners behind them, but the counter attack and pursuit on the water, which makes it very difficult for them to get home again, and we should undoubtedly, where there are ships in harbour, have a certain number of destroyers or similar craft not only to deal with submarines, but also to prevent the enemy's boats from getting back to their ports. And I am sure the gunners will realize that whatever the designation of the defenders, and whatever their uniform and whether they work afloat or on shore, it is above all things necessary that they work together. (Applause.)

Colonel H. BARRON, R.A.:—General Slade, ladies and gentlemen, might I first as a garrison gunner thank Mr. Jane for his kindness in coming here and lecturing to us as he has done this evening. Last year when he lectured on the defence of our fortresses he gave us the greatest possible encouragement, and told us that we were very likely to be attacked and that our chance would come. Admiral May I think seems to take the contrary view, that we as Garrison gunners are of little use as we should never be attacked.

Mr. Jane has mentioned the subject of the co-operation of the Army and Navy and I am sure nobody more heartily wishes for it than I do. And he also mentioned picket boats and other boats which might be employed about our harbours to protect us. I can only say that I sincerely wish naval officers would work more thoroughly with the soldiers than, according to my experience, they do at present. I was present at the torpedo-boat manœuvres at Milford Haven this year. We got continual warnings from the look-outs at the sentry beams of the approach of apparently hostile torpedo-boats. These latter proved in nearly every case to be our own friendly boats which were either returning to harbour or waiting about the entrance to watch for the approach of an enemy. The gunners were never informed of the intention to use these boats in assisting the defence and the result was that friendly boats were occasionally fired at. I have constantly in these manœuvres seen friendly torpedo-boats fired at, but in every case the gunners on shore were not to blame.

Then Mr. Jane has mentioned the subject of the distribution of fire, that is to say, what arrangements should be made to insure that no hostile craft escapes being fired on. It is to all garrison gunners a very difficult problem. It has been talked about I am sure in every coast fortress, the people on the spot have discussed it and they have devised what they consider the best system. I think it must depend entirely upon local considerations; you cannot lay down any hard and fast rules upon the subject. The only thing you can do is to impress upon everybody the importance of it.

Then Mr. Jane talked about the lights and the question of attacking our lights. I must say I think myself that we have not gone sufficiently into the question of shuttering our lights, that is to say, putting out some of our lights until they are really required.

It need not be necessary to expose some of our lights till the actual torpedo-boat attack was imminent. We must, however, be certain of an efficient system of warning from outside of the imminence of the attack or the defence might be caught napping.

I maintain that we cannot efficiently protect our harbours from torpedo-boat attack unless the Navy will help us with boats for scouting. Three years ago I was at Plymouth during naval attacks by destroyers. I went out one night with Captain Hamilton, who was in charge of the flotilla, and just outside our lights there was a destroyer at anchor without lights waiting to run in when the mist, which was very probable, came on in the early morning. The gunners are tied to their guns, they cannot go out in boats and reconnoitre, and I think it is highly important that they should have some means of communication with outside to show if anything is waiting to come in.

As regards the question of the 12-pr. gun for defence against torpedo-boats. Some few years ago at Shoeburyness I was mentioning to a distinguished Admiral the number of hits per gun per minute we hoped to get on a torpedo-boat. His answer was "Why talk of the number, one in the right place would be sufficient." The engine room space is, I believe, something like $\frac{1}{10}$ of the length, and one 12-pr. shell should be sufficient, not necessarily to sink the ship but to stop it. Of course we have other ways of stopping it, either by driving it on mud, or by the destruction of the *personnel.*

I think it is a pity that the majority of the old heavy muzzle loading guns, which used to be at the entrance of comparatively narrow channels, have been removed.

Their value with heavy case shot against torpedo-boats has been conclusively proved in practice recently carried out at Sheerness. All officers who witnessed the practice were of opinion that no boat could have lived in the hail of bullets.

Then Mr. Jane mentioned the subject of the Army having full control. I am sure we shall be delighted as soldiers to take full control and do everything. I fear, however, that his suggestion that gunners should take out the torpedo-boats and the sailors take the shore defences in our next manœuvres, might be an expensive one, resulting in the expenditure of some of the boats.

A great deal, however, is being done and valuable information obtained by the presence of Artillery officers on torpedo-boats when an attack takes place.

The CHAIRMAN:—Ladies and gentlemen, as nobody else seems inclined to add any further remarks to the discussion and it is getting late, I think I may sum up with a few remarks of my own.

I should like in the first place to ask Mr. Jane if the harbour entrances which were attacked at Wei-hai-Wei were defended by electric lights?

Mr. JANE:—They are supposed to have been lit from lights from the fleet, but they were probably defective lights.

The CHAIRMAN:—Because of course that would make a very great deal of difference to the facilities of entry by the torpedo-boats.

Mr. JANE:—I cannot say for certain how they were lit, but there were no fixed beams certainly. It was always spoken of as being quite dark as they came in.

The CHAIRMAN:—Then with regard to picket boats; we are told that in war time the land defence will receive no assistance whatever from the Navy as regards scouting, and I think that the occasion which Colonel Barron alluded to just now, when friendly boats scouted outside Milford Haven, was strongly in opposition to all custom and to what would really occur in warfare. The question of the examination service has never been touched upon, either by the Lecturer or during the discussion, but such a possibility as that of a friendly boat coming in, in the way described by Colonel Barron would be almost an impossibility if the examination service had been carried out correctly.

Much has been said about disguising tordepo-boats, but I am of opinion that this will not be resorted to in time of war. To disguise a boat by adding masts, yards, extra funnels, higher bulwarks, &c., would seriously interfere with her navigation and action, and just at the time that the highest speed and greatest invisibility is required, the boat would find herself hampered by these additions. In the course of my inspections, I have seen some very curious disguises, and one was in the case of a destroyer. They put an extra funnel in her, repainted the hull, and lit her steaming lights, and then towed an old smack towards the harbour, with the result that directly she got to the examination line the whole thing was discovered, and the ruse failed.

Another was in the case of a torpedo-boat disguised as a yacht. The weather was very calm, there was no wind whatever, but at one moment she was at a bearing of about 280°, and in two or three minutes after she was at about 250°, and any gunner would know that that boat could not possibly have sailed that distance in so very short a time. I do not think any disguise which hampers a boat's action will ever be adopted in time of war.

With regard to the question of Maxims in quick firing batteries, I think they are necessary in Q.F. batteries, and also at dock entrances. Mr. Jane mentioned the possibility of a destroyer throwing her own light on the defender, and I think that is a very important matter. I saw an instance of that very thing last year, and drew attention to the possibility of its occurring in war, asking that the question might be considered. The destroyer came in very fast indeed and immediately she was lit up she opened fire with all her guns and turned her search-lights on the batteries. The effect was curious. It dazzled all the men in the batteries, and certainly interfered with the laying, but I think the lights showed her up to such an extent that she must have been sunk. However, what struck me most, was, that she appeared to draw the fire of all the batteries just for the moment, and as there was another boat behind her, which had no lights, the latter certainly had a very good chance of getting in.

As regards an attack by torpedo-boats on dock gates, it must be remembered that the outer gates, as a rule, are not those leading directly into the dock itself, but into a chamber, or outer dock, the water level of which, is the same as that of the harbour; so that when a submarine or torpedo-boat has forced the outer gate, he still must negotiate the inner one, which is his real objective, and to do this in the face of a few machine guns and infantry rifles, and impeded by the débris of the outer gates, will be a hazardous, if not impossible undertaking. Speed or immersion will not assist him.

I quite agree with what Colonel Barron said about the distribution of fire. I consider it a matter of the very greatest importance, and one that should be very carefully studied. No hard and fast rules can be laid down, and every fortress should have a special scheme, worked out with regard to the local conditions, viz., the configuration of the coast line, the position and breadth of navigable channels, rise and fall of tide, shoals and banks, position of other guns of the defence, illuminated areas, arcs of search-lights, &c.

With regard to what has been said about the co-operation between the two services, I think it is a matter that is receiving the consideration of every one, and I notice that of late years it has much increased, especially abroad, where the officers of the two services are so much more thrown together socially. When commanding the Artillery at Gibraltar, the Admiral always appointed an officer, generally a Gunnery Lieutenant, to be attached to my staff during combined operations. He lived with me, and made notes of both the action taken by the defenders, as well as what the enemy did from a defender's point of view. This was of great assistance to me in drawing up the results of the operations, and was what you may call satisfactory co-operation. I recommend that this should be done oftener. (Applause.)

With regard to search-lights, I quite agree with what fell from Colonel Barron, that you cannot douse the lights that are absolutely at the entrances to ports, but there are harbours where there exists a second line of lights, and I think that that second line of lights in the rear of the others, ought to be kept doused until the alarm is given. A point which has not been touched on is the possibility of the electric light emplacements being destroyed by gun fire, and the necessity for their better protection. This is a serious question, as it is quite possible for a cruisers, supporting a torpedo-boat attack, to lay out on a flank, and concentrate her fire on an electric light emplacement, whose light is not directed on her.

I do not think there is anything more I can add. I have only to thank Mr. Jane very much for the lecture he has been kind enough to give us, and I would be very much obliged if he would be good enough now to favour us with any remarks he may have to make upon the discussion that has just taken place.

REPLY.

Mr. JANE:—General Slade, ladies and gentlemen, it being late, I must keep my remarks within as short a compass as possible. With regard to the question of dock gates which was referred to by Admiral May, I think, although the damage that might be done may be very little, the point is that there seems to be no scheme in existence for defending them at the present moment. The ships may be lying in harbour, but it is certainly not the duty of the ships in harbour, as things are now, to look after the entrance to the dockyard, and there are no forts there to do it, and that is why I am suggesting in particular the defence of dock gates, so as to take away all chances of mischief in that direction as far as possible.

I think we may say that torpedo defence is looked at by the Navy as an entirely naval matter and by the Army as an Army matter—that is to say, that torpedo-boats from the naval officers' point of view come in simply with the object of trying to smash a ship, but I think we might realize the fact that there are lots of things they might do in the way of mischief. For instance, there is the moral mischief, and the moral mischief they might do, looking at the matter entirely from a torpedo point of view is this:—Inside Portsmouth harbour there are ships and coal hulks and other things which they might destroy, and the moral effect of this would be very great. Indeed, I fancy that if the boats got inside and did nothing at all, the fact that they had been in would be a moral victory of value to them.

Then with regard to the question of divided control, that is a matter which I feel very strongly upon and have written a good deal about. It appears to me that we may make as pleasant compromises as we like and we may possibly devise some means by which the two services might act generally in unison, but there is no guarantee that they would do so, and although we may hope and say that they should be quite agreed with regard to the line of defence, the question of defence is such a very vague subject and a subject upon which so many opinions exist, that it is quite likely the two arms would hold diametrically opposite opinions. If they do what is going to happen to the defence? We rather ignore this and leave it to luck. We simply say we hope it will be all right, but I do not think we can be sure of securing that unison to which I have just referred. As long as we have got a system that part of the defence has got to be looked after by one arm and part has got to be looked after by the other arm, each having different ideals, we run grave danger. I am still of opinion that the proper *rôle* of the Garrison gunner is not the mere "privilege of rendering the Navy such assistance as he may be able to supply." I cannot but feel that that is a very wrong view. We have to think of facts as they are to-day—it is no good bothering about how the thing worked in the Nelson period. In the next war, ships coming into harbour will come with crews dead beat, and they will come to rest these crews. I think, therefore, that the entire defence of the harbour should be left to the military; if the matter be left undecided till war is on us, a muddle is the best that we can expect. I can see nothing in divided control except assistance to the enemy.

Then upon the question of the 12-pr. and the single hit, except in the case of hitting a boat, I am afraid I must disagree with Colonel Barron on the ground that I do not think anybody in the Navy would believe it. A great deal of study has been given to the question of how much hitting boats can stand, and I found that all of those whom I have ever consulted upon the subject are strongly of opinion that it is absolutely impossible to sink a boat right away with anything less than a 6-inch. Their contention is that if a boat is coming in at the rate of 30 knots her way will carry her on, and that is what they base the thing upon. The average torpedo man is of course in danger of being unduly enthusiastic about his craft. Still, I fancy it will be safer for gunners to think boats more difficult to sink than they actually may be than to hold the opposite opinion, and so underestimate the attack.

The question with regard to Maxims which was raised by General Slade, I have already referred to before. About the dockyard gates and the protection of all things inside the harbours, and the thinking out of all these matters. I think the main question is:—What will be the effect of the attack; what will the enemy be going for; what mischief can he do if he gets inside? To apply this to every base and then to guard in the case of every individual harbour against the particular attack that threatens it most. (Applause.)

The CHAIRMAN:—Ladies and gentlemen, I will now ask you to allow me to close the meeting with a vote of thanks to Mr. Jane for his very interesting lecture. (Cheers.)

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Coast Defence from an Imperial Standpoint.

BY

COLONEL E. W. COTTER, h. p., R.E.

Wednesday, 17th February, 1904.

MAJOR-GENERAL SIR HUGH MACCALMONT, K.C.B.,
in the Chair.

In a lecture limited in duration to one hour it would be impossible to treat the subject of Coast Defence in detail; I therefore confine myself first to a general outline of the principles on which, in my opinion, coast defence should be based, and follow with an illustration of the application of those principles.

A statesman has recently told us that he could never get an answer to the question: "What is the object of the British Army?" At last we seem to be agreed that to answer the question correctly it is necessary to study our whole Imperial position. Only when we have done that can we arrive at a sound decision as to the size and constitution, not merely of our Army, but of all the Services connected with national defence.

I asked myself, "What is the object of coast defence, what should be its nature, and what its extent?" and I came to the conclusion that, like the rest of the Services connected with national defence, it should be treated on the broadest lines, because its object, nature and extent will depend on the relative power of our Navy, and the objects for which that Navy exists.

My argument is as follows:—

1. It is of vital importance to us to have command of the sea, in order to keep open our Imperial communications and protect our seaborne trade. If we fail in that we fail in all, and coast defence would be worthless.

2. As we must keep command of the sea, we do not require coast defence to protect us from invasion by a large Army; the utmost that we need fear is raiding by small forces, which can most cheaply be met by placing small mobile garrisons near such points as are of sufficient importance to tempt a raid.
3. In order to keep command of the sea, it is necessary to secure permanently throughout a war those harbours whence our Navy draws its ships, its men, and its stores, and, in order to give freedom to our seaborne trade, it is necessary to secure our principal commercial ports.
4. If we relied on our sea-going fleets to secure permanently the safety of our naval bases and our chief commercial ports, it would be necessary to have, within striking distance of each such place, a fleet equal to the whole fleet of the enemy in being at each period of a war—a wholly impossible idea.
5. It *is* possible to secure the harbours by defences placed on or based on the land, without inordinate expense.

The first four points I consider truisms which require merely to be stated: the last point, however, requires to be supported.

The truth of the point depends on two main reasons. First: In order to secure our harbours by land defences, it is not necessary to have anything like the power which would be required if we relied solely on a fleet, because the land defences need only have sufficient power to ensure that an enemy will suffer more loss in getting possession of the harbour than we will suffer by losing possession. The strength of the coast defence of a country like ours, which has to retain command of the sea, does not depend on the strength of its weakest defended port: it is sufficient to defend each port relatively to its importance. As far as I know, this theorem, on which all our coast defences should be based, has never before been publicly formulated; but common-sense has brought about nearly the required result, for we have never fortified unimportant places as heavily as places of more importance. None the less, I think it is of manifest advantage that the principle and the reason for it should be enunciated. The theorem does not apply to defence by a fleet, because the very existence of that fleet would induce a superior hostile fleet to attack and destroy it, after which the port, if not otherwise defended, would be at the enemy's mercy.

The second reason in favour of the altogether greater economy of coast defence as compared with defence by a fleet is the fact that our only do we require less power, but that this lesser power can be obtained on land at far less expenditure in men and money.

Apart from the axiomatic reasons that on the land you have not to build expensive vessels to float your works, there is a reason which requires argument in support.

Within its arc of fire, one gun on land was always superior to one gun on a ship, owing to its stable platform, and the fact that such platform could not be sunk. I make the reservation contained in the words, "within its arc of fire," because the ship, being mobile, could sometimes place itself outside the arc of fire of the guns of the defence and yet bring its broadside to bear on them; but this advantage usually existed when short lines of defence were dealt with; against long lines it should have been rarely possible.

The often expressed view that in smooth-bore days, ships were superior to shore batteries arose from forgetting that success was almost invariably due to superiority in number of guns. People knew, but did not realise that even two-deckers had an average of about 70 guns apiece, so that, counting even but one side, three sail of the line had a broadside of over 100 guns. Did anyone ever hear of a line of batteries, having 100 guns on the water front, being reduced by three ships; or of any important case where the relative number of guns available were in similar proportions?

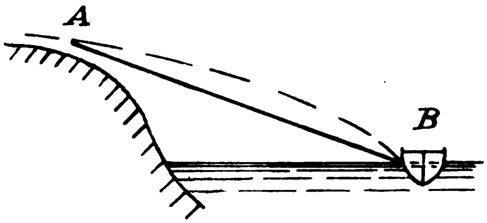
In those days ships had greatly concentrated gun power, which, when they could lie close to a low battery, enabled them to overwhelm the defence by sweeping the parapets or pouring projectiles through the embrasures; but this concentration of power could have been given to the shore batteries quite easily. It was not often given, because open earthworks were so much cheaper.

Whenever it was possible to defend navigable waters by placing guns at a high level, then the land gun entirely dominated the gun on the ship. As the ship had to lie off at least as far as to enable its own guns to hit the battery, it was no longer possible for it to sweep clear even open earthworks. Hits on the ramparts inflicted little or no damage; to effect anything a gun or an individual man had to be hit directly, not an easy thing at some distance with inaccurate smooth-bore guns fired from an unstable platform; while the land gun had still a target it could not miss, for every hit on the ship was effective. A consequence of these facts was that, at high levels, it was no longer necessary to shelter land guns by placing them behind the parapets and making them fire through embrasures; but they could be placed *en barbette*, thus largely increasing their arcs of fire, and rendering it rarely possible for a ship to take up a position whence it could hit the battery without being hit back. In the well-known case of the naval attack on Sebastopol, the Wasp and Telegraph batteries, which were 115 feet above water, beat off with their ten guns of which they lost but one, two of our ships, mounting altogether 140 guns, say 70 on the broadside, and then caused the abandonment of the whole attack.

The introduction of rifling increased the advantage of the land gun, because fighting could commence at longer ranges, because the increased length of effective range enabled a channel to be defended from a larger choice of positions, and because the increased accuracy of the gun could be more fully taken advantage of from a stable platform. All these advantages increased as the range and accuracy of rifled guns increased after their first introduction.

The invention of automatic sights, which require a stable platform, has once more favoured the land gun, where high positions are available. The principle of the automatic sight can be illustrated by Fig. 1.

Fig. 1.



Assume a gun at A and a target at B, then the line A B is the line of sight. If you know the height of A above water and know the depression of the line of sight, you know the range. If, then, you can arrange that as the sights move vertically the gun will move simultaneously in such a way as always to have the elevation above the line of sight corresponding to the range, then the gun layer has but to bring his sights to bear and, without estimating the range, or waiting to have the range passed to him, or, in either case, having to alter his sights to suit the range, his gun has the proper elevation.

The principle was, of course, always known, the difficulty was to apply it, for it demanded not merely seperate sighting gear for each pattern gun, but for each pattern at every different height above water. It also demanded almost perfect mechanism in the mountings, and almost perfect accuracy in the laying of the platform. But when quick-firing mountings and rapid loading arrangements were invented, the advantage of having some quick method of aiming became strongly apparent, and, owing to the development of mechanical engineering, the problem was solved, in large measure by Sir George Clarke, whose name now looms so largely before the public.

Such is the theory of automatic sighting; how about the practice? I am not a gunnery expert; but I have seen practice with both the old and the new sights, and can say that when I first saw practice with the latter I was literally astonished. With sufficient height relatively to the range, I thought the efficiency of the firing was at least doubled.

Theoretically, of course, automatic sighting is accurate from any height above the water; but, like all things made by man, it is in practice liable to error. When the angle of depression of the line of sight is very small then a small error in sighting will cause a large error in range, and as a result, fire with the ordinary sights, though slower, might be more effective; hence the necessity for height if the advantages of the sights are to be properly utilised. I am not prepared to lay down law—I leave that to some gunnery expert—but as an indication to those present who would like to have some idea of the matter I can state that from a height of 60 feet with medium guns good practice can be made with automatic sights up to a range of a mile and a half. From a height of 240 feet the range might be about three miles. Realise then the advantage of being able to follow the ship through your sighting telescope always having the range, and always ready to fire when the gun is loaded, and you will have a good idea of the position.

From the foregoing series of arguments, I submit that I may thus sum up my case so far as it has gone. That coast defence with us must be wholly subsidiary to naval requirements, using the word "naval" to cover both our war and mercantile marine; that coast defence resolves itself in our case to harbour defence; that though we must have command of the sea we cannot rely on having that command everywhere at the same time throughout a war without intolerable expense, and that hence some cheaper form of securing our naval bases and our principal commerical harbours than defence by fleets is necessary; and, finally, that this coast defence can be provided without extravagance by land works because at each harbour it is only necessary to provide defensive power proportionate to the importance of that harbour and because such power as is required can be provided on land incomparably cheaper than on the water.

Having stated the principles on which I think our coast defences should be based, I will give an illustration of the method in which they might be carried out in an imaginary case, indicating how at almost every step our two great Imperial interests, naval supremacy and freedom of commerce, should guide our arrangements.

Let us consider the case of an imaginary harbour, with two entrances, to illustrate an important point. See sketch, p. 114.

It can be readily understood that a simple way of defending a harbour is to block it altogether against entrance, as the Russians did at Sebastopol; but that if we have to afford free ingress and egress to our friends and deny them to our foes, the problem requires more complicated and more expensive arrangements.

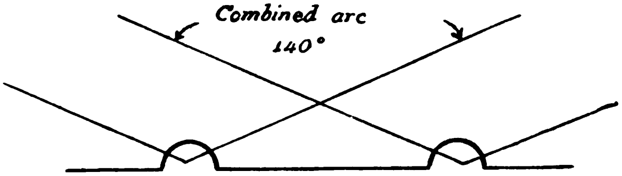
With us, harbour defence must be entirely subsidiary to the interests of our war and mercantile marine, and hence we cannot adopt the cheap passive defence except where a harbour has two entrances, when possibly it might be admissible to adopt that form at one entrance. If this be done it should be no secret; the fact should be publicly announced.

In the case we are considering, I assume that one entrance may be closed to both friend and foe. As the navigation of the western entrance is easier than that of the eastern, I choose it as the one to be kept open, thus sacrificing the purely defensive view to the requirements of our own ships. A nation with a weaker Navy and less dependence on its seaborne trade might very well reverse the procedure. At the western entrance every step taken must be subsidiary to the necessity for affording reasonably free passage to our own ships.

I assume that the harbour has importance on the whole equal to that of Plymouth, which has an important dockyard on its shores.

The accompanying sketch will enable those who are not experts to realise what I mean when I use the term "combined arc of fire."

Fig. 2.



The figure represents a ground plan of a battery. From a centre on the right front there are two lines drawn, making an angle of 140° between them, and a similar pair of lines on the left front. These lines represent the limits of the arcs of fire of guns pivoting on each centre respectively. The inner lines cross in the centre, making again an angle of 140°. Now, the outer area beyond the crossing enclosed between these two lines is within the combined arc of fire, that is to say, that, as in Q.F. batteries, the gun on the right may not fire within 20° of the direction of the one on the left and *vice versâ*, only the area I have just defined is under the fire of both guns.

It is not considered admissible to place Q.F. guns closer than 40 feet apart. My own opinion is that the distance should not, except for strong reasons, be less than 50 feet, on account of the effect of noise and blasts from a gun fired so nearly in one's direction as 20°, because, though small, they are rapid-firing guns. With medium guns the distance apart is 100 feet, and with heavy guns 150 feet, and as both heavy and medium guns may not fire within 30° of the direction of an adjoining gun, the combined arcs of fire are reduced to 120°.

I have described these arrangements in some detail because I would like to add an opinion to the effect that though the distances suffice when a detachment has only one gun other than its own in the same group, they do not suffice when there is a gun hammering away at each side. I would like to see all guns in groups of two, and, when there is more than one group on the same terreplein and on the same general front, I would give spaces between groups at least 50 per cent greater than the interval between the guns of each group.

To return now to my harbour, I will deal mainly with the western entrance, which, as it has to be kept open, is the more important.

The line A B indicates the ordinary course of navigation taken by ships entering the harbour. In our case it would be wrong to alter or interfere with freedom of navigation along that line; it should be kept well clear of obstruction and no defence light so powerful as to dazzle the eyes of pilots should be allowed to shine too directly along it.

The necessity for giving freedom of navigation to our own ships raises the question of distinguishing friend from foe. It is a very difficult question.

Some years ago, during naval manœuvres, I commanded at a defended harbour, my main duty being to try a method of meeting the difficulty. The method was found too complicated, and has been abandoned. Though I may not even now describe the method tried, I should like to say something about what took place.

On two occasions the defence gunners fired on ships belonging to our own side, and a special correspondent of the *Times* wrote a series of diatribes against the military on the strength of a signal which had been communicated to him. I wrote shortly in reply to the effect that as the instructions governing the entrance into defended harbours in time of war were strictly confidential, the correspondent could not know what he was writing about. I did not then add, what I now can, as the system has been abandoned, that the correspondent's ignorance was so complete that the answer to his diatribes was contained in the very signal which he took as the foundation for them.

The correspondent's letter started off a host of self-constituted authorities. One original person said that no matter who was to blame it would be little satisfaction to the nation if it lost two of its own ships in time of war. Good heavens, what on earth were we doing but trying a method of preventing that, and how could we try the method if we did not rigidly adhere to its instructions? Did the man really think that our gunners are to recognise all our own ships even in the dark, and pass them whether they comply with the regulations or not? Please understand that I am not saying who failed. That is not necessary in this case, for the writer said it did not matter who was to blame.

Another individual of the same class took up the text. I must mention one of his charges, as it is instructive. In the course of pointing out that our methods of coast defence in some ways were foolish, inasmuch as they were more injurious than advantageous, he said that it was our practice to disregard the necessities of our own ships and sometimes threw powerful search-lights in the eyes of navigators so that they could not see. Such may have been done in making trials; but so little truth is there in the charge that I need only answer that, for upwards of seven years at least, no defence light has been permanently installed without the Board of Trade being first informed of the position of the light and the direction in which it is intended to shine, and permission obtained for erection.

Lieut. Colonel Maude, lecturing recently at Aldershot, condemned the scurrility with which the officers of our Regular Army were attacked by many special correspondents during the recent war. Though it is often the privilege of "Our Own" to be wise after the event, how very wrong he often is even when he has that privilege. Their very profession induces among gentlemen of the Press an effort at omniscience, with the consequent tendencies to dogmatic judgement on matters of opinion, and pretence at knowledge when they don't know.

I have said that the system tried was abandoned. I do not know what the present system is; all I know is that it is something very unlike the one tried by me. But I must give a general idea of what, in my opinion, must be included in any system in order to show how it governs the whole scheme of defence against large ships.

Near the mouth of every defended harbour there would be a war signal station. So far from trying to keep its position secret, I would during peace publicly announce the position in which it would be placed. The duty of this signal station would be to communicate with every ship approaching the harbour. Everything secret in the way of communication would be here carried out. If the replies of the ship were satisfactory, it would be given permission to keep on its course; if not, the batteries would be informed so as to fire at or to warn off the ship. It follows that batteries should be placed so as to command as far as possible the whole area within the purview of the signal station. Merely to give satisfactory answers to the signal station ought not to give complete entrance; it should only allow vessels to enter an area wherein they can be boarded and examined. As the weather would often prevent this being done in the open sea, the examination area must be fairly sheltered. The inner limit of this area, which should, in my view, be made publicly known for every defended port during peace should be a line with a definite bearing from some point which is marked on all charts. Ships crossing the line without authorisation would be fired on. Manifestly, to guard against a ruse, strong defences should exist to cover some area behind this line.*

Whatever the system adopted, I can say with absolute conviction that all the arrangements governing the entrance to defended ports in time of war should be in charge of the Royal Navy. The Army should have nothing to do with them, except when informed by the Navy to fire at an inimical or warn off a doubtful ship. One great point is that the regulations should be so clear and so well known that friendly vessels can make no mistake.

Now, as to the application of this system to the harbour we are considering. I place the signal station on Signal Point, which I prefer to Marconi Hill, which is often enveloped in mist; besides we want the closest inspection. As to the examination area, mere inspection of the plan indicates that the narrow part between West

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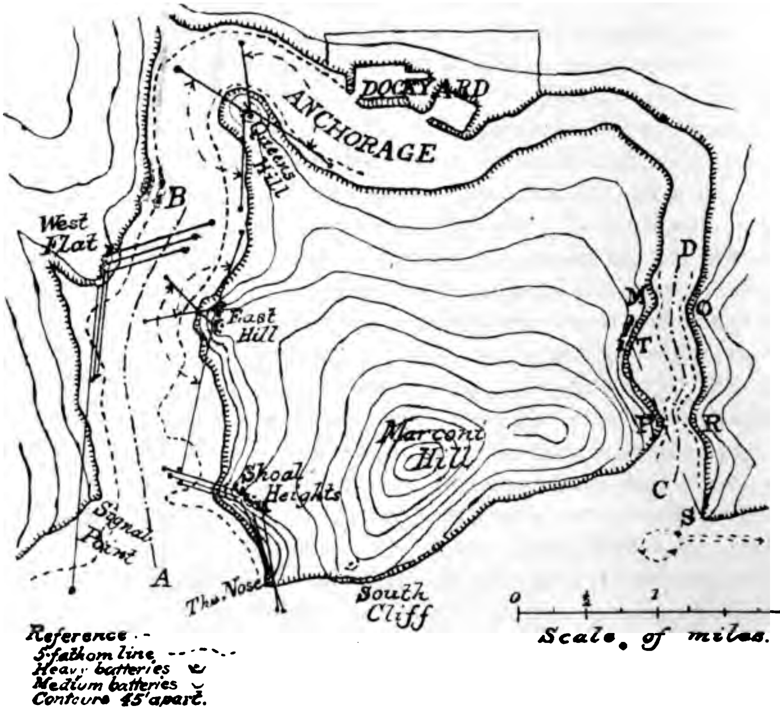
*It must not be thought that this forms a complete scheme, it is only a portion of a scheme; there would necessarily be many other regulations.

Flat and East Hill is capable of strong defence, while outside it is a fairly well sheltered area. I therefore assume that the Navy would be asked to fixed a well-defined line across the channel, a little distance below the narrows, so as to give time to the defence, and yet not so far down as to unduly limit the area in which the examination will take place.

IMAGINARY HARBOUR.



The point I have now reached is a good one for discussing the question of a mine-field. Whether a mine-field is to be placed or not is purely a naval question. If not provided, the gun defence must be stronger. In this case I assume that it will be provided, and naturally place it across the narrow part. Again you may ask—Will our own ships run risks? Practically none. I am divulging no secret when I say that no nation dreams of using mines which explode on *mere* contact; if they did, there would be many cases of the sapper being hoist with his own petard. Contact mines are more dangerous to friend than foe—the latter may not come near them, the former would have a ticklish job in laying and removing them. All mines are fired by an act either as deliberate or nearly as deliberate as firing a gun. But as there are objections in our case to a continuous mine-field. The main ones are that our own ships passing in and out would damage the mines and their connections, while the cables might entangle the screws of passing vessels. For these and other minor reasons we should have a friendly passage through the mine-field along the ordinary course of navigation. The width of that passage should be fixed by the Navy and the Board of Trade, but I can conceive no case when it would be necessary to make it more than 300 yards wide. In the case in point, its sides might be 150 yards at either side of the line A B, in which case, as the channel at the narrows is about 1,200 yards wide, three-fourths of it would be absolutely barred to big ships, and only be passable to torpedo-boats if they were prepared to sacrifice, not merely the leaders, but a second and possibly a third line as well, a loss that would probably act as a strong deterrent.

But as regards torpedo-boats, we want to be "sure"; probable safety is not sufficient. We may not interfere with the friendly channel, but surely we can anchor booms behind the two mine-fields, along the line between the north corners of East Hill and West Flat. As the channel is 1,200 yards across, and the friendly channel 300 yards wide, this would mean two booms, one about 500 yards, and the other about 400 yards long. Such booms would so back up the mine-field that we could say with absolute certainty that no torpedo-boats could get in except through the friendly channel. The booms would have an incidental advantage, because they would force bargees and such like truculent navigators to keep clear of the mine-field, which they might otherwise damage in passing.

I read the other day a review of an American book on Coast Defence, from which I gathered that the author proposed to place a mine-field out to sea in front of the entrance. This seems to me an extravagant proposal in any case, but also an inefficient one, for in such a position the mines would be exceptionally liable to damage, and there would be great difficulty in repair. At any rate, such a proposal is utterly unsuitable to our conditions.

I have now prepared the way for a description of the gun defence. This divides itself into anti-torpedo-boat defence, to which I barely allude to-day, and defence against large ships.

Defence against large ships is divisible into three, though all three overlap:—

1. The outer defence.
2. Defence of the channel.
3. Defence of inner waters.

The object of the outer defence is to keep the enemy well off the port and cover the area overlooked by the signal station. The sketch sufficiently indicates the area covered by the guns, which have their full arcs of 120° to the open sea, and which can all be brought to bear on ships making the entrance, while the right-hand guns of each battery can follow an enemy for varying distances up the channel. The two outer batteries have each two heavy guns; the inner one two medium guns. It will be noticed that the point called "The Nose" defilades the batteries from any position whence they might be attacked without all the guns being able to reply; that is to say, all the area from which the batteries can be seen is within the combined arc of fire. The sites are high.

To defend the channel from the mouth inwards I naturally select the narrows. As the outer edge of the plateau called West Flat makes an angle of nearly 30° with the direction of Signal Point, it can be arranged for all the guns to cover the channel right round from Signal Point as far as the combined arc of 120° will permit. Included in this arc are the whole of the narrows, so that the weak point—the friendly channel—is under a powerful fire. Though the height of the guns is only 60 feet, it is enough to allow the use of automatic sights at all ranges inside the entrance; in fact, just where they would be most useful. As Signal Point is not high enough to hide the batteries from the sea, it is advisable to throw back the line a bit so as to give fire over the point,but I would not do that at the sacrifice of a single portion of the fire over the friendly channel; especially as ships trying to enfilade the batteries from a position whence their fire could not be returned by all the guns they were firing at would, at any rate, be under fire of the right-hand gun of the right battery, besides the fire of the guns on Shoal Heights. I think three batteries of two medium guns each will suffice for this site. It can be seen that all the guns include in their total arc of fire an arc of about 50° to the open sea, which enables them to strengthen the outer defence.

Though East Hill is not so suitable for a line of batteries defending the entrance, one can place on it batteries with different fronts. My design is a battery of two heavy guns with an arc of fire that covers the deeper part of the entrance and the open sea beyond, through an arc of 25°, and continues to the right till it includes the friendly channel underneath. I arm this battery with heavy guns, so as fully to take advantage of the height of the hill. Further in I place on the same hill a battery of two medium guns which, while including the friendly channel within their arc of fire, cover with the rest of it an area inwards and not outwards. This brings me to third section of the gun defence, namely, that of inner waters.

I know that high naval and military authorities are opposed to this class of defence, but I know that equally high authorities of both Services are in favour of it. It is a question which should be thoroughly examined and settled. Its object cannot be defence against large battle-ships or cruisers, for no admiral would be mad enough to send ships costing a million of money, and taking from two to three years to build, to rush a channel defended by mines and heavy guns, knowing that after they have got in they have to get out again, if they are not to be lost to him. This class of defence cannot be meant against torpedo-boats for, as they would invariably attack at night, they could not be seen, for who would think of lighting up waters in which his own ships were at anchor? I have sought for an object, and think it can only be that, prior to declaration of war, an enemy might open the ball by sending ships of little value to destroy peaceful shipping lying in the harbour, and to blow up dock gates and do as much such-like damage as possible till they are sunk.

To resist this class of warfare perhaps medium guns would suffice. In the case in point the battery on East Hill, which assists in defending the friendly channel, might cover, as shown, the reach inwards. On Queen's Hill two more guns with an all-round fire could be placed. The combined arc outwards includes raking the narrows, while the inward arc covers the anchorage and the waters off the dockyard.

A better way of meeting a raid made by large ships before declaration of war is to prevent the enemy from getting in by taking the necessary steps when war seems imminent. Supposing the Navy were not prepared to prevent such a raid at all harbours, and that the one under consideration required to be protected by the land service, I would recommend that the whole or part of the regulations governing entrance should be introduced in good time, and then rely on dirigible torpedoes. A dirigible torpedo will certainly sink a ship attempting to rush a channel, unless the navigable portion be over a mile from the torpedo installation. Now, supposing that the minefield has not yet been laid, and that the artillery garrison has not yet been brought up to war strength, still, if the torpedo installation be ready, and be large enough to allow, say, three torpedoes to be fired in succession, I think such a raid would fail.

I have said that gun defence of inner waters cannot be intended to destroy torpedo-boats. If a raid by a number of these little craft were made before we were ready with our full anti-torpedo-boat defence, I don't see how to stop it; at any rate, it cannot be done by the land service. In my opinion, dirigible torpedoes are of little value against a mosquito fleet; to use them thus would be like firing cannon balls against a line of skirmishers. The lesson seems to be: "Get ready to meet a torpedo-boat attack immediately war seems probable."

Looking at such a defence as I have described, you will observe that consideration of our own naval requirements has been my guide throughout.

"What!" it may be said, "you consider eighteen heavy and medium guns sufficient to defend such a harbour with an importance equal to Plymouth?" My answer is Yes, in combination with a mine-field covering three-fourths of the narrows and a dirigible torpedo installation capable of firing three torpedoes in rapid succession. Recollect that I have hitherto been dealing with an attack by a fleet, not with a raid by torpedo-boats, for such require separate treatment. I believe such a defence as I have indicated, if it did not beat off an attack *á outrance* by a large fleet, would inflict such damage on it before succumbing that all the damage the victors could inflict inside would not repay them. Realise that the victors cannot land to any extent, for riflemen could shoot down the landing parties, and every defended harbour will have an infantry garrison. The main damage the ships could do would have to be done by torpedoes and by shell fire. It dare not do much of that sort of thing, else it would be at the mercy of the first battle-ships of ours with full magazines that arrived on the scene. I say that no attack by a fleet alone is likely to be made on such a port under any circumstances; and to expect it, when the enemy can only have temporarily command of the sea at this point, is to give him credit for folly—folly which we should be glad for him to commit.

Then why defend it so strongly? Because I may be wrong, and the expense involved is not great, and, moreover, it may be considered desirable to dispense with the mine-field at one time or other. One should not be too cocksure. Many high military authorities thought one army corps with the Indian division and such troops as were in South Africa in October, 1899, would suffice to conquer the Boer Republics. I confess I thought so, too. Well, we lived to see the equivalent of six army corps carrying on the war for many months.

Should it be thought that more should be done, I would put a battery of heavy guns on South Cliff, where shown, which could join in the defence of the western entrance, and prevent a ship circling off the eastern in the manner indicated by the dotted lines.

Time prevents me from dealing with the question of torpedo-boat raids, but the details of such would not materially help to illustrate the matter looked at from an Imperial standpoint. I desire, however, to indicate a few general points.

The defence lights which should steadily illuminate the outer area should emanate from East Hill. If they were placed on West Flat the one that looked due south would shine directly along the line A B, which would interfere with the free navigation of the entrance.

Another point, and one of vast importance, is this: I have laid stress on the enormous cost of modern men-of-war, and the time it takes to replace a lost one, and indicated how little likely an admiral would be to waste them against land works. For precisely the same reason how necessary it is to protect these valuable machines from being destroyed by a mosquito fleet. What a prize for torpedo-boats if a raid by, say, twenty or thirty of them, managed to sink three or four battle-ships; what matter if all the boats were lost, it would still be a victory.

*Just as I think that we overdo our defence by heavy guns, so I think we are apt to underdo defence against torpedo-boat raids. While I think few will support me in thinking such a defence against large vessels as that I have indicated would suffice if the harbour were as important a commercial port and naval base as Plymouth, I believe that the anti-torpedo-boat defence which I would recommend would be scouted as altogether overdone.**

When I settled that the eastern entrance was to be blocked, but little of importance from a national standpoint was left to say concerning it. Suffice it to say that I would cover about half the basin with mines from the narrows at M O southwards, that across M O I would place an exceptionally strong boom, and to prevent armoured boats from coming in to destroy the obstructions I would have four medium guns. For night work I would have simply one search-light placed at T, where it would be defiladed from the open. As it would not have to carry far I would give it a 30° splay, so that it could light up a considerable area at the same time. Against a torpedo-boat raid, if such madness were attempted, I would assist the heavier guns with four quick-firing guns. I would place the medium batteries to the left of the light, so as to cover any position whence the light could be hit, with the quick-firing guns to the right of the light.

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*These two paragraphs were written and handed in to the Editor, R.U.S.I. JOURNAL, before the news of the outbreak of war arrived. Since then no word has been altered.

In case it were considered desirable to make arrangements, while denying entrance to *all* vessels, to allow egress to our own torpedo-boats, the matter would scarcely be altered, for the consequent passage through the mine-field need only be thirty yards wide, and, if commencing at a movable portion of the boom near O, and directed in a S.W. course on leading lights inside P, there would be but little loss in defensive power. Even if egress for large ships were required and, in consequence, a wider and more direct friendly channel became necessary, the only changes I would make would be to light up the whole basin and double the number of Q.F. guns. The defence would be assisted by a battery placed on South Cliff, before referred to, for it would prevent a ship from circling off the entrance and making practice by firing at the boom and the mine-field, while avoiding the guns of the defence.

In the early part of this paper I said that it is only necessary to defend a harbour relatively to its importance. Suppose my imaginary harbour, instead of having the almost constant value of Plymouth, were to be a mere coaling station for the fleet, then how different its value, according as a fleet is anchored inside or not. In such a case, what value should be put on the harbour when deciding on the strength of the land defence?

Here again the question of defence against large vessels and against a mosquito fleet must be kept separate.

As regards defence against large vessels, I would merely rank the port at the largest non-effective value that it is likely to have inside, including under the head of non-effective not merely colliers, store-ships, and merchantmen, but also an allowance for ships of war temporarily out of action. I would add nothing on account of effective fighting ships, because, just as they add to the value of what is inside, they also add to the defensive power.

Against torpedo-boat raids the matter is altogether different. If the harbour be within striking distance by torpedo-boats of any foreign port, then, if the harbour be likely to have a fleet anchored inside for any considerable period, the anti-torpedo-boat defence should be nearly as strong as if the harbour had the importance of Plymouth, because in neither case should torpedo-boats be allowed to get in. I say *nearly as strong*, because a fleet while inside could lay down a minefield and a boom, or add these defences to such smaller mine-field as maybe considered sufficient for the ordinary case of the harbour. Here again it is a question for the Royal Navy to settle: How much extra will they be prepared to do in such a case, and, consequently, how much shall be done by the military? Please note carefully that in saying "nearly as strong," I only include mines and booms, for in both contrasted cases the number of defence lights and the number of Q.F. guns should be precisely the same.

In concluding my paper, I would ask whether the time has not come for handing Coast Defence over to the Royal Navy. As it is entirely subsidiary to naval considerations, why bring in division of responsibility, especially as such division is most acute at the very place where there is most difficulty, viz., at the entrance? Such a proposal does not mean abolition of our Fortress Artillery or Fortress Engineers, it merely means that those bodies would be included with the Corps of Royal Marines. In every large fortress the whole defence on the sea front would be in charge of the Navy, that on the land side of the Army, the duty of the governor of the fortress being to make them perform their separate duties for the common end. Such a division of duties and separation of responsibility seems to be simpler and more logical than a system which involves joint responsibility, first, for every question connected with the principles on which the defence should be based, where naval considerations alone should be paramount; and, secondly, joint responsibility at the very place where mistakes are most likely to occur.

Admiral F. ARDEN CLOSE:—Permit me to thank the lecturer for the information he has given us. If there is a fault to find in the lecture, I would say it is rather more scientific than practical, for this reason: Submarine mines are unreliable, and are useless against disguised gunboats. We have recently had an instance of self-destruction, by a ship being blown up in the face of the enemy while trying to lay mines at Port Arthur. I hoped that as a Royal Engineer was to give us a lecture on coast defence, we should hear what was ready for the defence of the coast. The meeting may remember that in years gone by schemes were proposed by foreign officers for the invasion of this country, and at the head of that list always appeared the Bristol Channel. I made it my business to look after those defences, and found that they consisted of two fortified islands called Flatholmes and Steepholmes, with a battery called Brean Down to correspond with it on the mainland. The guns were old and almost useless, and there were no gunners or garrison; nothing ready for immediate defence. The mayor and people of Bristol petitioned the Government that the coast defences of the Bristol Channel should be reorganised. We have now a gun-boat, Naval Volunteers, and six new batteries. That leads up to a question I wish to put to the lecturer: Do you, in constructing these maritime forts, seek the advice of naval officers? I do not mean the naval officer stationed at the War Office; but whether a naval officer goes down to these maritime forts, and sees that they are constructed not only theoretically but practically? Without the assistance of a naval officer no maritime fort can be as serviceable as it should be. The other question I wish to ask is: Are our maritime forts ready? Because if they are not ready, what is the use of them? as war will come upon us like a flash of lighting. Again, take the Thames—another weak point in our defences. As I stood on the banks of the river at Tilbury and saw the enormous number of merchant-ships flying by on the flood tide, I asked myself: How are we going to stop this? Any one of these ships might have a charge of dynamite on board; any one might be a gun-boat in disguise. I wrote a letter to the *Globe*, and the Editor was pleased to put a heading: "London bombarded; London in flames!" Two powerful forts have since been built between Tilbury and Sheerness. London is now safe from general attack; but if Germany was to declare war on Monday morning, they could have a couple of disguised gun-boats up in the middle of London by the next night. These maritime forts have no means of knowing the difference between a friend and a foe under false colours, and when it comes to disguising gun-boats to make them look like a merchant-ship and and under false colours, they would not be interfered with at all. I say that London will never be safe until we always have a couple of gun-boats stationed there, because at the present moment if gun-boats got up past Tilbury to London, there is nothing to meet them but a police-boat; there is no knowing what havoc the gun-boats might do. They might blow up the bridges, destroy the Houses of Parliament and the docks and shipping; also Woolwich Arsenal and the magazines at Purfleet. Londoners do not understand that London is no longer an inland town, and is as much exposed to attack in these days of steam power as Hull, Liverpool, or Glasgow. London is under military protection, and as it is impossible for them to perfect that protection without the assistance of the Navy, I submit they should ask for that assistance now, not waiting for the outbreak of war.

Colonel R. F. JOHNSON, C.M.G., R.A.:—I happen to have been the Artillery officer in charge of the Severn defences for two years, and I am happy to say that while I was there there was no insubordination nor drunkenness, and the forts were perfectly ready for action. I cannot say that it would have been much good to man them, because at that time the guns had not been replaced by new ones; but with regard to manning them, we had a most excellent and very strong corps of Volunteer Artillery in Cardiff, within half-an-hour of the nearest fort, and within two hours of the farthest fort. The men were perfectly trained with all the guns that were in those forts. The lecturer has given us an example of the application of what he considers are the principles of coast defence. My practical experience makes me afraid of principles when they are applied to such matters. It was principles that led to several of our home ports being fortified on a scale calaculated for a total of garrisons amounting to 67,000 men. The principles that have led to the conclusion that the heavy land defences of some of these forts are not necessary, have caused those of others, whose conditions are entirely different, to receive insufficient attention. The adoption of principles in placing guns has in some instances prevented the best use of the available sites. I know a work in which the changes in the conditions attaching to ships has made it desirable to alter the direction of the "combined arc of fire." When I discussed this with an Engineer officer I was told it could not be done, because the site did not admit of its being so, and of retaining the regulation distance between the guns. We did not want the arc of fire to be near the guns. Where we wanted a combined arc of fire was a considerable distance off, so that the blast need not have been taken into account. The principle, which in itself is perfectly correct, that high sites enable better practice at targets from cheaper works, has prevented the use of low ones, which from their proximity to the channels that must be used by ships would enable us to make use of the greatest power of our guns, if they were armoured and protected in the way those on the ships are, which is our only chance of denying the passage to a determined assailant. I entirely agree with the lecturer when he says that a harbour with an importance equal to Plymouth may be sufficiently defended by 18 heavy and medium guns; but whether Plymouth could be defended by that number is quite another matter. If the guns were of sufficient power, properly placed, and sufficiently protected, even a smaller number might suffice. And it is especially necessary to limit your armament and fortifications nowadays, because it is more important than ever that they should be just as ready in every way, including their garrisons, for action as the ships that they have to fight. The only principles that I can accept with regard to coast defences are that they shall be strictly confined to places where the Navy thinks them necessary, and that their extent and cost shall bs as small as the local conditions, strategical and tactical, admit. I am sure that there might be a great saving made in the annual cost of our sea fortresses, though possibly a considerable capital expenditure might be necessary to enable this to be done. Whether you should defend the entrance or the inner waters of a harbour depends on the strategical conditions, on what damage to that which you are defending is worth to the enemy, and on what he can afford to pay. Can anyone cite an instance of batteries stopping completely the passage of a channel? If such an instance can be given, it is certainly the exception that proves the rule, and the chances of armoured ships getting through are now better than they have ever been. Suppose Port Arthur contained the only Russian dock in the far East; suppose that the Japanese Fleet had either a ship or two to spare, or was too weak to meet the Russian Fleet in battle; then, if the Rusisan Fleet was elsewhere, would it not in either case be worth while for the Japanese, whether in decided superiority or decided inferiority, to risk the loss of a ship or two, if the absence of inner defences gave them the chance of destroying the dock? It seems to me somewhat lost sight of, that in defending channels by guns, and more so by mines, there is, in not a few localities, a danger of blocking with the sunken ships the channels it must be your object to keep open. I am entirely opposed to the proposal to hand over coast defence to the Royal Navy. The proposal is tempting to a Garrison Artilleryman, for in the work of defence the Navy must have more interest than the Field Army. We should get more money for the adjuncts necessary to develop the full powers of our amament; we might get rid of the principles of fortification, but the corps would suffer a deadly injury in having its chances of active service reduced to almost nothing, and the disadvantages to the Navy would be out of all proportion to any possible gain. All naval energies should be directed to offensive action; and, with our Constitution, it is necessary that the Naval Estimates shall not be burdened with any expenditure not required for that offensive action. A Coast Defence Corps, entrusted with both the designing and fighting of the defences both seaward and landward, maintained on separate estimates, and at some places largely composed of partially-paid local troops, might perhaps be an improvement on our present organisation; but that is a large matter on which I should be sorry to be asked to give a decided opinion, for though the idea meets some views worthy of consideration, it has the great objection of locking up large numbers of men and officers, and in such a way as to lower their *moral* and zeal.

Lieut. Colonel F. G. COTTER, R.M.L.I.:—It is only with reference to the last paragraph of the lecture that I rise on this occasion, because on such a highly technical lecture that we have just heard it would be absurd for me to make any comments on the details. There was one matter wth reference to the defensive arrangements that struck me—and always strikes me—as a weak point, and that is the defence lights. It appears to me to be essentially a very vulnerable point, especially at night time, when of course their location is at once seen, and would be the object of raiding parties landed on various parts of the coast, and also open to attack from quick-firing guns carried by destroyers. I have heard it said that you cannot aim a gun at an electric search-light; but that is not my experience. I say that you can aim a gun at an electric search-light, and probably hit it, too. If the searchlights in the harbours like Plymouth or on the Thames were destroyed at night, what is to prevent torpedo-boats coming up the very next night? That is all I wish to say with reference to defence. The only other matter I desire to refer to is the last paragraph in the lecture, namely, the proposition to hand over the fortress defence to the Navy. The author mentioned the Royal Marines as being the soldier body of the Navy, suggested that the Fortress Artillery and Engineers should be, I suppose, amalgamated with the Royal Marines. We know that this subject has been brought up in this theatre on various other occasions, notably by Sir John Colomb, and we know perfectly well that the Admiralty have always set their face against it. I presume the reason that the Admiralty has always done so is lest the efficiency of the men-of-war should suffer through not having the men constantly on board, because, of course, it would mean increasing the Marine Corps to probably about five times its present strength. Another thing is that the Admiralty have recently reorganised the system of entering officers into the Navy. The officers are now entered so that they may be practically interchangeable wtih all three branches. We have no experience of that as yet, but we know perfectly well that the system has alreadv been commenced at Osborne in the Isle of Wight. The result is that the future naval officer will have quite enough to learn. He will have to learn his seamanship up to a limited extent, I suppose, but certainlv to a certain extent; he will have to learn his naval gunnery and his torpedo work; and he will now have to learn marine engineering and military work, as the present marine officers do, in addition to which he is apparently to have piled on him the work of the defence of sea fortresses, so that it would result in the naval officer of the future being rather overburdened with work, and he would become a sort of Jack-of-all-trades. Then, with regard to the Marines, we know that the Admiralty consider them a very valuable body of men on board ship. Some people think that Marines are of no use on board ship. My experience is that on asking naval officers whether they would like twenty additional men attached to their vessel, and whether they would have them seamen or storkers or Marines, I have nearly always been told that they would rather have twenty additional Marines, which shows that the Marines on board ship are thought very highly of by the naval officers. The Marine, of course, would lose his value very considerably if he only spent one year in ten at sea, because I see the lecturer proposes to man all the sea fronts of all fortresses with Marines,or, as he says, men from the Navy. But he does not tell us who is to command these fortresses, whether they are to be naval officers or military officers. In one part of his paper he suggests that the sea fronts shall be defended by the Navy or Marines, and the land fronts by the Army; but that is also a divided responsibility. We therefore do not know who is to command the fortresses. It may be a naval officer. If so, he would also apparently have command of the land forces on the land side.

Admiral the Hon. Sir EDMUND R. FREMANTLE, G.C.B., C.M.G., (Rear-Admiral of the United Kingdom):—I have not read the lecture, and consequently I do not feel entirely competent to criticise it in every way. I shall, therefore, confine my remarks chiefly to the question of principles, and also to some things which I think show the way in which we ought not to defend our ports. I take exception to the fourth principle laid down by the lecturer, that "if we relied on our sea-going fleets to secure permanently the safety of our naval bases and our chief commercial ports, it would be necessary to have, within striking distance of each such place, a fleet equal to the whole fleet of the enemy in being at each period of a war—a wholly impossible idea." I venture to think that is a false idea of strategy. I admit that we did not fortify Wei-Hai-Wei on that principle. We say that if we were to fortify Wei-Hai-Wei we should have to fortify it against the attack of a fleet, possibly a Russian fleet from Port Arthur, and, therefore, as we do not propose to put up extensive fortifications there, we do not put up any at all. I do not think that is the right principle of strategy. If there is a Russian fleet in Port Arthur we ought to be able to mask that fleet; we ought to keep it in hand, which the Japanese are doing at present. On the same principle I think this one laid down by the lecturer is wrong. If there is an enemy's fleet somewhere at Cherbourg, and we have got a sufficient fleet, we should be more or less watching that fleet. Even supposing our fleet was away for a little time, and the French fleet could manage to slip out, would it be a wise thing for that French fleet to come to Plymouth, to do a certain amount of damage, but in returning to be knocked about as well, possibly to lose the whole of their fleet? After all, if they lose the whole of their fleet it does not very much matter if we have lost the dockyard, as they certainly would lose their fleet, because our more powerful fleet would intercept it. But nobody does do that sort of thing. In the books that we read sometimes—we have not seen so many of them lately—called "The Coming War," and so on, you generally see that the fleets fight in a sort of Kilkenny cat fashion. I well recollect one that I read some years ago, in which the Russian fleet was supposed to go up the Tyne and do a certain amount of damage there, losing ship after ship, and, eventually, fortunately for us, the whole Russian fleet was destroyed. That is the sort of thing which is absolutely and entirely unreal; it is not the sort of thing which takes place in real warfare, and consequently it argues a great want of sense of proportion to propose that it will be done. I have only one other remark to make, and that is on the subject of whether defences are proper to the circumstances of a particular port or country. I should like to refer particularly to some defences near Plymouth on the west side, where a system for high-angle fire, which was very much in vogue about ten years ago, was adopted. When I was in command at Plymouth, I recollect going round with the Commander-in-Chief (Lord Wolseley), Sir Redvers Buller, and others, to see all these defences—chiefly high-angle fire batteries, which were supposed to be very important, and to embrace the latest improvements. I was asked: "What do you think of them?" I said: "I have no opinion as to their firing, because I have only seen the guns fired once or twice, when they did not make as accurate shooting as I am told they did on other occasions; but if they made the most accurate shooting in the world they are absolutely useless. The best thing you can do is to blow them up." I do not know what has become of them now; but they were absolutely useless, because the assumption was that some Power—not a Power that I know anything about—had the entire command of the sea, but had no land forces. It would not think of landing an army in the Yealm or in the Thames, or anywhere else, because it had no army. That was the assumption. But it had any amount of mortar-boats and a large fleet; and the assumption was that it would lie somewhere in Whitsand Bay and would shell over the heights into the dockyard, with the chance, after throwing a very large number of shells, as we did at Sveabourg, that they would do a certain amount of damage to the dockyard. That is an assupmtion which, strategically, is entirely wrong. And that is not the only instance I know of, because a Zalinsky gun was put up near Pembroke to prevent an enemy's fleet lying outside and throwing shells from Bristol Channel over the heights into Pembroke Dockyard. I will only quote those instances of the way not to do it. What we do want, I venture to think, is a certain amount of direct defence, mine-fields, quick-firing guns to protect them and a certain proportion of heavy guns to prevent the enemy coming directly into the port. Those guns would be proportionate to the position of this country, which is supposed to be, and, I hope, still is, the greatest sea Power in the world; and she would naturally be supposed to have command of the seas; and if she had not command of the seas we know perfectly well that no amount of deences will enable her to retain her place among the nations.

Colonel F. A. BOWLES, R.A.:—There are one or two questions I should like to ask the lecturer, which, perhaps, he will answer afterwards. In his lecture, Colonel Cotter states that "I am divulging no secret when I say that no nation dreams of using mines which explode on mere contact." I am only asking for information, but I have an idea that when the electro-contact mine, as it is called, is put in working order, it does go off on contact. The lecturer rather conveyed the idea that the firing of a contact mine was just as deliberate an action as the firing of a gun; but I think I am right in saying that as soon as the mines are put in a dangerous condition the ship does the rest. I think we may safely say that some nations dream of using them, and we know that one nation lately—if the accounts in the newspapers are correct—has certainly suffered from using contact mines. With reference to the boom at the western entrance, I understood the lecturer to say he proposed to put two booms across what he called "The Narrows," *i. e.*, 1,200 yards, leaving a friendly passage of 300 yards between them. I am not an expert in referenec to booms, but I hardly think a boom 450 yards long would be manageable; and unless stone piers were built out to a very considerable distance, I think no boom could possibly be fixed in the western entrance. Even the eastern entrance, I think, is a little too wide to erect a boom. I believe it is an understood thing now that booms will not be very often used, probably for the reason that there are very few places which are suitable for them. I think at both the western and the eastern entrances booms would be rather unwieldly things to work. Supposing a boom at the eastern entrance *was* placed in the position which the lecturer suggested, I think we must raise the question as to the position of the electric light, because the whole of the boom would be in the full light of its beam, and I think it is not an accepted principle that the boom itself, if you have an illuminated area in front of it, should invariably be in darkness. I think it would be useful if the lecturer would say something in reply in regard to that point. I should like to be allowed to say a few words in regard to some of the remarks that have been made since the lecture. With reference to the heavy and medium gun defence, I think all our coast defences now are founded on the principle that England must have command of the sea. The lecturer in his lecture asks, why have heavy and medium guns. I think the simplest answer is: In order that we may never have to use them. What I mean by that is that I think our heavy and medium gun defence is more a preventative than a form of defence that is ever likely to be of any great practical value, because as long as we have command of the sea no serious attack on any of our well-fortified ports could ever be successfully attempted by any country. With reference to anti-torpedo-boat defence, I endorse what little has been said by the lecturer. I cannot help thinking that every possible occasion should be taken advantage of to impress on anybody who has to deal with our defences the vast importance of a thoroughly organised and good anti-torpedo-boat defence. We have had no practical experience until very lately of the rapidity with which these attacks will be made. We have always said in our text-books that torpedo attacks will be made probably before war is declared and that has certainly been justified by recent events. What we want is a very strong anti-torpedo-boat defence. The lecturer has also said a good deal about another subject which is still in a rather embryo state, *i. e.*, the very great difficulty of distinguishing friend from foe. The lecturer pointed out what he considered would be a good system.

Colonel E. W. COTTER:—I beg your pardon; it was a general outline.

Colonel F. A. BOWLES:—Probably a great many of the audience know that what the lecturer considers an outline of a good system is practically a fair description of what acually was tried at the recent naval manœuvres. It has many faults; but no system, in my opinion, that has been tried yet, can be looked upon as a pefectly successful system. It is almost impossible—I should say it is quite impossible—for anybody, even a naval expert, to be able to tell at night the difference betwen his own torpedo-boats and the enemy's torpedo-boats when an attack takes place, no matter what the rule may be. Supposing the rule is that friendly torpedo-boats, if they are moving about, are to advertise their presence in every possible way by showing all their lights and sounding their sirens, I have always maintained that it would be very easy for the enemy (who would know more about our arrangements than a great many of us know ourselves) to do the same, and, as far as we can judge from what we have read in the newspapers that is what the Japanese did do; they showed all their lights; they came in as though they were friendly torpedo-boats, and by that ruse they got quite near to the Russian ships before the Russian ships knew it—if they ever did know it—until the torpedoes had actually taken effect. It is difficult to know how much to believe of what one reads in the papers; but if we do believe what we have lately read, we know that the Russians have not only sunk their own torpedo-boats because they were thought to be Japanese boats, but they have also allowed their own ironclads to be torpedoed by the Japanese because the Japanese torpedo-boats were thought to be Russian boats. If both those accounts are true, it only enforces still more the absolute necessity of our having some system of knowing without any doubt at all whether a torpedo-boat moving about at night is an enemy's boat or not; and that really is the crux of the whole thing. I think with our present system of defence of guns and lights, provided they are properly arranged to begin with, which is most important, that we are in a more advanced state than some of those who have spoken since the lecture are aware of. I think we should make a very good attempt at keeping torpedo-boats out, if we knew for certain that they were the enemy's torpedo-boats. It seems to me that the only possible rule which will meet with any success is that no friendly small boats are to move about at all during the hours of darkness, otherwise it gives the gunner absolutely no chance at all. A young subaltern of the Garrison Artillery, in command of two guns, cannot take the responsibility upon himself of firing on boats unless he is perfectly certain that they are the enemy's boats, while if he hesitates half a moment he is lost; he will never have the chance again. Torpedo-boats, once they are seen in the illuminated area, do not give you a very long time to fire at them, and if you are not ready to begin on the instant the boat is visible over the sights or through the telescopes of your guns, you get no chance. Therefore I say it is absolutely necessary to lay down the rule that no friendly torpedo-boats are to move about at night within any waters that are defended by guns. I should like to be allowed to make one or two remarks about high-angle firing, because some remarks have been made which rather tended to show that it would be just as well to blow up high-angle batteries altogether. I am rather an advocate for high-angle firing. I know that experiments were tried at Plymouth some years ago, and I believe it was because of those experiments that high-angle guns were condemned by a very large portion of the military world; but I am not of that opinion myself. I am certain that high-angle firing guns can be worked up to very fair accuracy, quite sufficient accuracy, I think, to make them extremely useful in certain waters. Of course, they are not applicable to many places, but there are certain places where I think they would be most useful; anyhow, they would have the effect ot keeping the enemy's ships on the move. I am open to correction by naval officers, but I have heard it said that a naval officer funks high-angle fire more than anything. If it does hit, it hits him in a place where he has not much protection—the unarmoured decks, and I have always heard that it is a form of defence that the Navy will not run the risk of encountering. I just mentioned that because I am rather keen about high-angle firing, and I think it is a pity that it should be condemned without more experiments being carried out.

Admiral the Hon. Sir E. R. FREMANTLE:—I should like to say that I believe it is a fact that the Admiralty's arrangements are, on the whole, quite complete (whether they are sufficient is another question) with regard to the closing of ports, and also with regard to distinguishing our own vessels from those of foreign Powers. Those arrangements were practically completed before I left Plymouth five years ago.

Colonel E. W. COTTER, in reply, said:—It is very different thing to read a paper and have to speak extempore; but somehow I gather from the tenor of what has been said that although there has been a good deal of criticism, there is no disagreement with my general conclusions, except in regard to the one about handing the defences over to the Navy. That subject I left to itself, apart entirely from the rest of my lecture. I only raised that point because the result of my study has brought before me the fact that at every stage, no matter where, I was always confronted with the query: "What would the Navy want in the matter?" I was asked a direct question by one speaker: "Were the Navy ever asked?" All I know is this, that I always asked the Navy whenever I came across any naval officer.* I know that the same idea that was condemned by one of the speakers about a ship lying outside the fire of the batteries and bombarding the dockyard from the open sea, caused a long discussion at one place where I was, and it was raised in the first instance by a naval officer. It was not the foolish military officer that raised the question on that occasion, and, as General MacCalmont knows, I did not believe it was a practical point. I say this because remarks were made suggesting that we do not do these things reasonably. I appeal to you whether I have not tried throughout my lecture to give a reason for every step I took. Throughout the whole of the paper I have put my own branch of the profession last, because I felt that naval considerations in regard to coast fortresses must be entirely paramount. Admiral Close said we are not ready. Why! I said that I see no defence unless we are ready. We must be ready. If there be, as I said in some part of my lecture, a chance of torpedo-boats doing destruction in a harbour before the declaration of war, the only thing for us to do is to get ready when war is imminent, and be ready when negotiations are broken off. I think it was Colonel Johnson who said he would prefer to have batteries on a low site. I disagree with him altogether. I have not the least doubt in my own mind about it; but he is entitled to his own opinions. It would be a reversion to the old argument. I would infinitely rather have one gun in the open with 120° arc of fire than three or four guns with 30° arc of fire, boxed up in a casemate where they are not so ready to fire.

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*I expressed myself very badly here. After lecturing for an hour on a theme, the text of which was that naval considerations should be paramount, I was naturally startled at being asked by Admiral Fremantle if I ever consulted a naval officer. Answers crowded into my mind, but I could not at the moment put them into words. Suffice it to give but one. A naval officer was consulted about every battery built under me during my tenure of command as C.R.E. He was consulted before they were commenced, and he visited them during progress.—E.C.

Colonel R. F. JOHNSON:—I was not talking about casemates. I said in certain cases batteries which have an all-round fire would be better at low site than a larger battery, because you get shorter range, and therefore much greater penetration.

Colonel E. W. COTTER:—Of course, if to get height you have to go a long way off, then the advantage of your height would disappear. If my drawing were put on a scale you would find that the slope of the hills* is 10°, so that the guns never lose more than about 100 or 200 yards range. Somebody said that the Navy should be confined to offensive operations. There is something to be said for that. Personally I think they should be confined thus:—Everything in which naval considerations are paramount should be done by the Navy. If it is offensive it should be done; if it is defensive it should be done; but that of course is a naval question. The question was raised about the anchoring of a boom. I do not see why a boom should not be anchored across the water where I showed. Of course, no boom would be 1,200 yards long; there would be two booms in the main channel, one at either side of the friendly passage. With regard to the torpedo-boats at night, I always understood that every torpedo-boat which attempted to enter a defended port at night would be fired at. There is one thing I should like to add before concluding. I have said that we are apt to overdo our defence by heavy guns, and apt to underdo our defence against torpedo-boat attack. In connection with that I may have been misunderstood. The officers who have been recently responsible for our coast defence have shown great insight and wonderful courage in the way in which they have placed but one gun where two or three guns were placed before; and with regard to what they have done against torpedo-boat attack, I can see no improvement possible. As to the style of the defence adopted, the only question is that I think we have not thoroughly realised how very necessary it is

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**i. e.*, the hills on which the heavy batteries were placed.—E.C.

to go a great deal further on the same lines. I am very much obliged to you, Sir, for taking the Chair, and to you, gentlemen, who have discussed the paper.*

The CHAIRMAN (Major-General Sir Hugh MacCalmont, K.C.B.):—We have listened to a very instructive lecture and a very interesting discussion, though I do not mean to say that the discussion was not instructive too; as far as I am concerned, it was very instructive. It occurred to me that the main point of the lecture is point No. 5:—"It is possible to secure harbours by defences placed on or based on the land without inordinate expense." I remember the case of Belfast Loch, where I lived some years ago. The place was absolutely undefended. It comprised a narrow channel leading up to a great manufacturing town and great ship-yards, which were practically at the mercy of any cruiser which thought it worth while to work round and do some damage. The Navy cannot command every port; it cannot be everywhere, and it would be quite worth the while of any cruiser to make a raid on a place like Belfast. I wrote many letters in the papers at the time I lived there to call attention to the great risks involved. Within the last three or four years the place has been adequately defended, and, as Colonel Cotter has pointed out, at quite a comparatively trifling expense to that of making the Navy responsible for everything of the kind. It appears to me to be a matter entirely of economy. There is one question I should like to ask the lecturer. Colonel Cotter said that these contact mines were entirely out of date. We were given to understand that no nation would use contact mines. But we read in the papers the other day that the Russians blew up one of their ships through it touching a contact mine.

Colonel E. W. COTTER:—If I may answer at once, I would say we do not know enough of what has occurred; we cannot rely exactly

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**Addendum*.—I gather from the discussion that I did not make myself clear in the last paragraph of my lecture. I wish I had said: "Placed under the Admiralty" instead of "handed over to the Royal Navy." I never intended that sea-going naval officers should come ashore and command land batteries, nor did that follow from the text. Again, when I said that the present Fortress Artillery and Fortress Engineers would be included with the Corps of the Royal Marines, I did not mean complete amalgamation, for of course the two existing Corps of Marines are not amalgamated. I meant that the Coast Defence Corps should bear the same relation to the Admiralty as do the two existing Marine Corps; but it does not necessarily follow that the new body would be sea-going, and therefore it does not necessarily follow that the R.M.A. and R.M.L.I. would get one whit less sea experience than they do at present.—E.C.

on what we read in the papers. But I think Admiral Fremantle said the other day in the papers that no nation would dream of using purely contact mines. You must, in addition to the contact, have another act, a very deliberate act. Of course, when that deliberate act is taken, then if you knock against the mines you blow yourself up. Whether the Russian arrangements were very bad or not, as I am not a naval officer, I do not say; but I cannot understand them. They may have in this respect done one thing by mistake, viz.: performed the deliberate act, so that when the contact occurred the ship was blown up. However, we cannot tell that until we know more about the details. But I do not believe they have used purely contact mines.

The CHAIRMAN:—Then I should like to say that one of the speakers inferred that the advice of naval officers was not taken in regard to these land defences. I know of one case in point in which nearly all the work was done on the initiative of an admiral, though I cannot, of course, mention either the man or the place. At any rate, I know in one most important case that it was entirely on the admiral's initiative certain steps were taken; and I remember his making the remark to me: "If you put guns of such and such caliber in a certain place no battle-ship will ever come near it." And the admiral's view was acted upon. I do not think there is anything else I need say, except that I am not altogether prepared to agree with Colonel Cotter's proposal to hand over the coast defence to the Navy. I am one of those people who think that everyone ought to be allowed to do his own business, and that all the land business ought to be done by the land forces. If it is a question of signalling, then the land forces, the Garrison Artillery, and so on, should be thoroughly educated for the interchange of all signalling with the Navy. There is a tendency for everybody to try to do everybody else's work. For instance, in the cavalry there are three men to one horse. Before you provide the three horses for the three men you proceed to mount the infantry. That is our way of doing business; it is a sort of Jack-of-all-trades plan, which I am quite certain is not conductive to efficiency.

I desire, on your behalf to propose a hearty vote of thanks to Colonel Cotter for his very able and instructive lecture.

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UNITED STATES ARMY.

EARLY DAYS OF THE ENGINEER SCHOOL OF APPLICATION

By

BREVET BRIGADIER GENERAL

HENRY L. ABBOT

Colonel, U. S. Army, Retired

ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.,
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The intimate connection which has always existed between the Engineer School of Application and the Engineer troops, renders a brief outline of the successive organizations of the latter important to an understanding of the former. Indeed to Company A under Lieut. Duane much credit is due for valuable technical researches, before the Civil War had demonstrated the necessity of a special School for this among other purposes.

ENGINEER TROOPS IN THE U. S. ARMY.

Subsequent to the Act of March 16, 1802, fixing the military peace establishment of the United States, there were no engineer troops in service, other than the Company of Bombardiers attached for a short time to the Military Academy, until Company A was raised by Act of May 15, 1846, to meet the exigencies of the War with Mexico. After its close the Company was stationed at West Point, except when it accompanied the expedition to Utah, although several detachments served in the West on duty with other troops in the fifties. At West Point the Company assisted in the instruction of the cadets in practical military engineering, but its most important duty was experimenting with different patterns of bridge trains to take the place of the rubber pontons which had proved to be ill adapted to the needs of the service. These investigations were conducted chiefly by Lieut. Duane, and when the Civil War occurred the results proved to be of immense value.

At the outbreak of that war Congress authorized, by Act of August 3, 1861, three more companies of engineeer troops, and by Act of

August 6, 1861, one company of topographical engineer troops, the engineer service at that date being divided between these two Corps. After their consolidation, by Act of March 3, 1863, four of these companies served as a Battalion attached directly to the Headquarters of the Army of the Potomac, performing gallant and distinguished service from Yorktown to Appomattox. Company E was recruited at Detroit in 1865. The Battalion organization was first formally recognized by Congress by Act of July 28, 1866.

The original organization of Company A called for 100 enlisted men. This number, and that of each of the new companies, was established at 150 men by the Acts authorizing the latter. In consequence of the reduction of the army after the war, the number allowed to be recruited for the Battalion was fixed in December, 1870, at 354 men; on July 1, 1871, at 301 men; on June 3, 1873, at 350 men; and on May 9, 1877, at 200 men. On August 5, 1884, the number was increased to 450 men. The first reduction occasioned the breaking up of the Posts at Yerba Buena Island and Jefferson Barracks, the reduction of Company D to a skeleton organization, and the transfer of Company E to West Point.

DISPOSITION OF THE BATTALION AFTER THE CIVIL WAR.

When the Army of the Potomac was mustered out of service at the close of the war it became a question what disposition should be made ot the Battalion. West Point it was foreseen would soon cease to be exclusively an Engineer Post, and moreover there were no buildings there available for so many men, and for the storage of the immense accumulations of engineeer materials in Virginia that were worthy of preservation. At Willets Point the temporary buildings of the Grant General Hospital would afford immediate accommodation, and it was decided to create there an independent engineer post under the direct control of the Chief of Engineers; to send Company A back to West Point; to send Companies B, C and D to Willets Point; and to send Company E to Jefferson Barracks, where were to be stored the accumulations of Engineer property remaining after the discharge of the Western Armies. Subsequently, under General Humphreys' administration, Company D was transferred to California in August, 1867, for such military duty as might be required by the Commanding General, taking station first at Fort Point and later at Yerba Buena I and Company A was transferred from West Point to Willets

arriving on September 3, 1867, being replaced by a small detachment from the Battalion; the instruction of the companies at the three Engineer Posts was to be prescribed by the Battalion Commander, even the Post returns being forwarded through him; he also acted as Superintendent of the Engineer Recruiting Service, officers of the Corps on other duty at several cities having charge of the enlistments. Such were the general conditions under which the Engineer School of Application originated. It really was divided between three Posts, prior to the abandonment of Yerba Buena Island and Jefferson Barracks in 1871.

When the Army of the Potomac was mustered out of service in the summer of 1865, General Duane who had been its Chief Engineer reported for duty to General Delafield, then Chief of Engineers. The latter asked what service would be agreeable to him, remarking that he was one of the first officers of the Corps to return to duty after distinguished service throughout the entire war in his legitimate arm of service. General Duane replied that he should like to command the Battalion of Engineers. General Delafield acceded, and he was ordered to take charge of the construction of the fortifications at Willets Point, and to command the new Engineer Post. Companies B and D were sent there to receive and store the engineer property, to be joined later by Company C which remained at Washington to collect and ship the stores. This work was in progress when in the autumn of 1865 my volunteer regiment was mustered out of service and I reported for duty to General Delafield. He assigned me to the charge of the construction of the fortifications at Fort Schuyler, and to the command of the Battalion of Engineers, then under that of the senior Captain, Brevet Colonel Harwood. I reminded him of General Duane's request; but he said the latter's health had suffered, and although he was in command of the Post I would be held responsible for the Battalion. Before I could assume command, I was not sorry to be ordered to report to General Humphreys for temporary duty on the Mississippi River, and it was only on June 1, 1866, that I finally took station at Willets Point.

Having long entertained the highest respect and esteem for General Duane, and feeling that our verbal instructions might cause misunderstandings as to our relative functions I had a frank explanation with him on reporting. He fully met the difficulty by at once issuing a Post order defining our relations as those existing between the Superintendent and Commandant at West Point; and from that time until the date when he was relieved from duty at Willets Point, in October 1868, we coöperated most cordially in endeavoring to make the service with troops profitable alike to the young officers who, it was understood, would be given a tour of duty at Willets Point immediately on leaving the Military Academy, and to the older officers who would find the comparative leisure useful for such professional reading as had been suggested by their experience in other fields of duty. It would be unjust to General Duane to fail to recognize the benefit I derived from his good advice in the effort, without special authority or supplies of any kind, to relieve the officers from the tedium of routine garrison life, which after the excitement of active field service could hardly fail to become irksome.

INAUGURATION OF THE ENGINEER SCHOOL OF APPLICATION.

In October, 1866, General Humphreys having recently succeeded to the command of the Corps made his first inspection of the Post. He asked many questions, and was evidently impressed with the importance not only of replacing the temporary buildings, already giving signs of deterioration, with structures better suited to the climate, but also of developing some well considered plan by which the new Post might be made to serve as a School of Application for officers and men alike, and thus contribute to the efficiency of the Corps of Engineers. The locality was well suited for the practical instruction of the troops in works of siege including land mining, in military bridge exercises, and in military reconnaissances of the surrounding country to serve as a basis for the study of defensive lines. The question for the officers was more complex, and should be developed with a view to meet the actual needs of young officers resulting from the fact that while admirably trained at West Point in the theoretical rudiments of their profession, and in many of the practical details of the military duties of all arms of service, they had still much to learn about the use and care of delicate surveying, astronomical and other instruments in constant use by the Corps of Engineers. Before the war this needful practice had often been given by early assignment to duty on the Survey of the Lakes, or on explorations for a Pacific Railroad, or for the demarkation of our International or State boundaries; but now that the first two or three years after graduation would be largely devoted to service with troops it was desirable to afford ample opportunities to master these details, without a knowledge of which

the officer was certain to find himself in respect to the civil employees of the Corps in the mortifying position of a young Infantry or Artillery officer attempting to instruct old sergeants without himself understanding the weapon. Many of the older officers had not forgotten such experiences in the days before the war, when there had been no facilities for acquiring these rudiments before actual work began. As to a post-graduate course of technical reading, it would in General Humphreys' view be inexpedient to resume at once the studies and recitations which for four years had occupied so much of the time at West Point. The young graduate should be made to feel that his school-boy days were over, and that he was now responsible for the use of the time available for reading. He had learned how to study and should be allowed to apply this knowledge in the identical manner which the duties of the Corps would exact during all the rest of his life. Any one worthy of his commission would soon begin the work, and the examinations for promotion would weed out sluggards. In a word, Willets Point should be a School of Application and not an under-graduate affair. Furthermore, as soon as means could be obtained, it should be made the special laboratory of the Corps where with the assistance of officers and enlisted men any investigations requiring experimental research should be conducted. Such an establishment had always been needed.

Such was the general plan which occupied the mind of General Humphreys and to which my local experience suggested no modification or improvement. I did, however, suggest the question whether, as some of the work that officers would be called upon to perform lay beyond the usual requirements at military posts, it might not be well to have some such official recognition by the War Department as had been given in the case of the Artillery School. He said he thought not, at least for the present. The plan would be tentative at best, and such official recognition might involve conditions that would require troublesome modifications later. The command of the Battalion carried with it the requisite authority for what was proposed, and in case of any question I could depend on his support. It seemed better to grope our way at first, until experience had indicated the best solution of the problem. Thus was inaugurated the Engineer School of Application.

At this time the roster of officers on duty with the companies was the following: Battalion Adjutant, 1st Lieut. A. Nisbet Lee; Battalion Quartermaster, 1st Lieut. D. P. Heap; Company A, at West

Point, Capt. W. H. H. Benyaurd, 1st Lieut. W. A. Jones and 1st Lieut. H. M. Adams; Company B, at Willets Point, Capt. C. W. Howell and 1st Lieut. L.C.Overman; Company C, at Willets Point Capt. A. H. Holgate and 1st. Lieut. W. R. Livermore; Company D, at Willets Point, Capt. F. Harwood, 1st Lieut. C. B. Phillips and 1st Lieut. W. H. Chase; Company E, at Jefferson Barracks, 1st Lieut. W. Ludlow, 1st Lieut. J. C. Post and 2d Lieut. E. A. Woodruff. Many changes, however, soon occurred.

These officers had all graduated at the Military Academy during the progress of the war, and had had no experience in the civil duties of the Corps. Furthermore the Battalion organization had not been recognized by Congress, and had been improvised to meet the needs of an active field service. Graduates on reporting had usually been assigned to a Company, making the Battalion a sort of headquarters when the army was stationary, but when a movement came the demand for engineers with divisions and brigades caused so many temporary detachments that the Battalion often marched under the command of the acting sergeant major. Indeed Lieutenants Lee and Heap, appointed by me on October 3, 1866, to take rank from the date of the Act (July 28, 1866), were the first legal incumbents of the offices of Adjutant and Quartermaster. On assuming command I had found the officer of the day receiving dress parades, 1st sergeants commanding the companies. Under such conditions the summer of 1866 was naturally devoted to establishing the usual routine of duty at a military post, and to carrying out Colonel Harwood's drill orders covering infantry, pontoneering and the construction of three field batteries. One of the latter, however, was tranformed into a typical mortar battery to illustrate the system developed in the siege of Petersburg. This pattern it was found could never be silenced, by reason of overhead splinter proof shelters placed between the mortar platforms and the traverse magazines, under which the cannoneers could find instant shelter against shells exploding over the battery. The construction at Willets Point was intended as a permanent type, but was removed many years after to give place to new officers' quarters.

The instruction order for the summer of 1867, when systematic work really began, prescribed the completion of this battery, the fabrication of materials gathered in the vicinity or received from West Point into gabions, facines, etc., and the construction upon a scale of $\frac{1}{12}$ of Vauban's 1st front, Noizet's front, and the German front used at Fort Alexander at Coblenz. One of the fronts was

to each Company, the working drawings to be prepared by the Company officers. One of Brialmont's fronts was added at a later day. The scarps and counterscarps, at first of marsh sod, were subsequently replaced with concrete; and the models proved to be useful in the verbal instruction of the non-commissioned officers, and interesting to officers visiting the Post. The utility of the practice even for the officers themselves was illustrated when I found a recent graduate attempting to construct his front on the ground with chain and transit, his theoretical instruction having failed to make him appreciate the use of drawings for that purpose. The course in pontoneering covered all details, including rowing, bridge building with wooden and canvas pontons, loading and unloading the wagons, etc. In infantry it covered company, battalion, and skeleton drills in the school of the brigade, bayonet exercise, and Heth's target practice. The latter, although required by existing War Department orders, was often ignored at military Posts; and, as will appear below, this early attention to the duty brought great credit to the Battalion when a few years later marksmanship became so conspicuously the recognized test of soldierly merit.

To trace from year to year the gradual development in summer instruction at the Posts occupied by the Battalion would exceed the limits of this paper. It may be found in the annual orders printed on the Battalion press by enlisted men at Willets Point. This instruction covered verbal questioning of the soldiers by their officers at the model batteries; the practical driving of mining galleries, the explosion of gunpowder and dynamite mines, the formation by small charges of cavities for camouflets in countermining; the construction and breaking of improvised bridges over dry ravines; the making of military maps by officers, non-commissioned officers, and selected privates upon the system defined by Battalion order in June, 1868, which had been adopted after large experience in the Civil War; the rapid multiplication of military maps by various photographic processes; no little practice in carpentry and masonry in the construction of the new Post buildings, a work which continued actively until 1875; regular drilling in a large circular building, 110 feet in diameter, floored with moulding sand, where the construction of batteries, parallels, saps and other works of siege on a scale of $\frac{1}{6}$ could be executed with great advantage, as I had seen practiced by the Royal Engineers at Chatham in 1873; and finally elaborate instruction in submarine mining, as will appear below.

For the enlisted men, the winter instruction order for 1867-68 prescribed the usual daily recitations of the non-commissioned officers in field fortification, ponton manual, and Infantry tactics, together with Company drills in the bayonet exercise and such other exercises as were suited to the season. The school for soldiers ordered by Act of Congress of July 28, 1866, was opened under the following regulations. Attendance to be voluntary. Those desiring to attend to meet and elect three of their number to constitute a School Committee for the season, whose first duty would be to prepare a classified list of the studies desired. The necessary room, with fire, light, blackboards, tables, etc., to be provided without expense to the scholars; ultimately the Post fund assisted in the purchase of books. This school proved highly successful, the Battalion containing many men desirous to improve themselves by study. Three departments, mathematics, languages and English branches were formed, including arithmetic, algebra, geometry, English grammer, French, Spanish, history, international law, geography and penmanship. Four officers were detailed in each department, one to be present on three nights for three consecutive weeks from 6.30 to 8 P. M., to hear and mark the recitations. This school was continued annually during my entire tour of duty, the instruction finally devolving upon the Adjutant and Quartermaster, as the other duties of the Company officers became more onerous. Theoretical instruction in the submarine mining service was also given later to the enlisted man, as will appear below.

THE ESSAYONS CLUB.

The problem how to make the winter season of 1867-68 pass pleasantly and profitably to the officers during the suspension of drills was not a simple one. The ordinary routine of garrison duty after years spent in active field service could hardly fail to become wearisome to men of mental ability. We had no funds or outfit of any kind. General Duane and I discussed various plans, and finally decided upon the following, suggested by the success of a similar voluntary organization formed among the officers at West Point to discuss the campaigns of Napoleon at regular meetings, some member in turn having previously secured the needful maps and reviewed the important facts by aid of the Library of the Academy. As our officers at Willets Point had just served with distinction in a great war, and had had no experience in the civil duties of the Corps, it seemed to be more useful for them to turn their attention to the latter, which could be done

by individual reading and the preparation of papers for discussion. The idea at once proved popular, and thus was originated the Essayons Club of the Corps of Engineers, which became the germ of the School of Application.

The active membership was composed of all officers on duty at Willets Point who desired to join, and they all did, and such other persons as should be unanimously elected; among them will be pleasantly remembered Mr. Oxholm, the Asst. Engineer at the Fort. The honorary membership included all other officers of the Corps of Engineers, and such others as should be unanimously elected. Original communications upon professional subjects were solicited from the latter, which if voted by the Club might be printed on the Battalion press, making its proceedings the means of disseminating valuable information. Subjects for discussion to be confined to scientific topics. Meetings to be held on Monday of each week during the season. At each meeting some member to read a paper upon a subject announced by himself at the previous meeting, either an essay or a compilation from authorities at his disposal. The order of papers to be determined by lot at the first meeting, and as often thereafter as necessary. After the reading a discussion to follow on that or on some other subject announced by the president at the previous meeting.

This plan proved highly successful. General Duane, on the occasion of the first meeting, held on January 28, 1868, read a paper on the experiments conducted at West Point to develop the best pattern of bridge train for the Army. This was followed by others, and general interest in professional subjects was soon awakened. Many of the papers, fifty in all, were printed from time to time on the Battalion press, some of them contributed by officers of high rank not stationed at Willets Point. As the technical work of the School increased meetings were held at longer intervals, and finally the Club died a natural death in 1882. The printed papers covered a wide range of topics pertaining to physics and engineering, and they form a worthy supplement to the Professional Papers of the Corps. They were followed by another series entitled Professional Papers of the Engineer School of Application of which two volumes were printed during my tour of duty. They were largely but not exclusively restricted to translations of such current literature as seemed appropriate to the objects of the School, both military and civil.

To attempt to follow year by year the gradual development of the School of Application would extend this paper beyond reasonable limits. The fundamental idea was the following. The study of natural phenomena with a view to a specific application of the information acquired constitutes so important a part of the current duties of the Corps that the time of the young officer could not be more profitably spent than by making him familiar with the methods common to such investigations. Reading can be done anywhere, research demands tools and skill in using them, and these are not to be had at ordinary stations of the Corps. It should be the function of the School to supply them.

METEOROLOGY IN CONNECTION WITH HYPSOMETRY.

The beginning was made with meteorology, for which alone the needful instruments could then be obtained. The Corps had made important contributions to hypsometry in conducting the explorations for the Pacific Railroad, and few instruments require more delicate handling or furnish better tests of the accuracy of the observations than does the barometer. In July, 1868, the eleven officers on duty with the Battalion, and Asst. Surgeon Calvin De Witt as a volunteer, each made hourly observations with extreme care for twenty-four consecutive hours, of the barometric pressure, the temperature, and the humidity. The usual reductions were applied and the results were published in Battalion orders, giving five mean horary curves.

These observations were continued regularly from year to year, the observers being the officers and selected non-commissioned officers at the three Engineer Posts; and the results were published in annual orders in the form of mean horary curves. These observations, and their reduction by the method prescribed in Colonel Williamson's Corps Paper, made the officers familiar with the latest developments in hypsometry, and the few hours devoted to them were well spent.

MILITARY RECONNAISSANCES AND SURVEYS.

The details of military reconnaissance next received attention. On June 30, 1868, was published a Battalion Order prescribing the method developed during the War for such work on foot and on horseback, and for its compilation into military maps. This practice was continued annually not only by the officers and non-commissioned officers but also by selected privates. Indeed, for many years small detachments served in the Western Departments and on the Wheeler Survey, and the Annual Report of the Chief of Engineers for 1876 records the fact that during three years these enlisted men reconnoitred and

mapped 24,044 miles, for the benefit of the Army. In the summer of 1872 reconnaissances near Willets Point were combined in a way to make a connected map of the district, and during the following winter the instruction order described: "Each commissioned officer of the Battalion, stationed at Willets Point, will prepare, in lieu of essays," (which had been required in the previous year) "a detailed project for a line of field works extending from Willets Point to Jamaica Bay, designed for the defense of Brooklyn against an anticipated sudden invasion by a well equipped army of 100,000 men, landing on the east end of Long Island. The project will include a plan (on the Battalion photographic map), sections, estimates of time and materials, with a full memoir showing the theory of defence. Our working forces may be assumed at 30,000 militia infantry, and three full companies of the Battalion of Engineers; our artillery to consist of 50 rifled siege guns and 50 eight-inch siege mortars, served by a full regiment of artillery, and of 30 six-guns batteries of field artillery, one-third being rifled. In addition to the needful quartermaster transportation, including forage, 1,000 horses will be available, and all requisite tools; of which, however, a list should be given." These projects were forwarded to the Chief of Engineers. At a later date, each officer was required to carefully survey and contour one square mile of territory, using the ordinary surveying instruments. Finally, as the distance from the Post increased outlying camps were formed for this purpose. One object of this practice was to impress the officers with the fact that while absolute accuracy is unattainable, no matter how perfect the instruments, a very close approximation ought to be secured even with rough methods, if skillfully applied.

FIELD ASTRONOMY.

Field astronomy was the next subject to receive attention. As the demarkation of all our International and many of our State boundaries has been confided to the Corps of Engineers, together with the Survey of the Great Lakes, and the exploration of the new and little known portions of our territory, every young officer should be an expert in practical field astronomy. Prof. Bartlett, who took a warm interest in the new School, kindly offered in February, 1867, to loan us the early astronomical outfit of the Military Academy. In the summer following he sent an astronomical transit, a zenith telescope, a telescope for occultations mounted equatorially, sextants, chronometers, etc. To properly make use of these instruments a field observatory was necessary, and funds were so hard to obtain in those days that it was only early in 1869 that regular observations could begin. All officers on duty with the Battalion were put on the roster and weather permitting the hours from sunset to midnight were devoted to the work. Each officer was supplied with the printed blank forms used by the Corps for recording the notes and making the computations; and as these after approval became his personal property they could hardly fail to be convenient at a later day if suddenly detailed on astronomical duty. As the latitude and longitude of the observatory would soon be accurately known, the former by many zenith telescope observations and the latter by time signals from Washington, the individual results of each officer were tabulated and announced annually in Battalion Orders, which thus became useful for reference in estimating the probable absolute errors to which simular observations and methods in the field are liable. This annual publication, which continued during my entire tour of duty, ultimately resulted in connecting our little observatory with the discovery of a new oscillating motion of the axis of the earth, as will appear below.

During the first twelve years fifty officers of the Corps had the benefit of practice, in this old observatory. The building was small and the instruments were of ancient patterns, but they were replaced in the spring of 1879 by a new outfit entirely satisfactory in these respects. The building was constructed almost wholly by Engineer soldiers. A lithograph showing its dimensions and arrangements was appended to Battalion Order No. 3, of 1881 (reprinted in Annual Report of Chief of Engineers for 1881), which also contained a full description of the instruments, about a dozen in number and including the latest types. Prof. T. H. Safford after visiting it remarked to me that in his opinion it was the best observatory in the United States for teaching practical astronomy. The regular course included determination of latitude by different types of zenith telescope and by the sextant; the determination of longitude by moon culminations, by occulations by the dark limb of the moon, by eclipses of Jupiter's satellites, and (for practice in using the sextant in oblique planes) by lunar distances. Any unusual astronomical event was of course observed and reported, as for example the transit of Mercury on May 6, 1878, in connection with which the longitude of the observatory was determined by time signals sent for ten days from the Naval observatory at Washington; and the transit of Venus on December 6, 1882, of which the results were reported in full in Paper V of the Engineer

School of Application. At the same time special observations were made to determine the correction for the right ascension of Venus as given in the American Ephemeris, which was determined to be plus 0.48 seconds; similar observations made with the Transit Circle of the Naval Observatory at Washington indicated a correction of plus 0.47 seconds. But the most interesting contribution to the science of astronomy for which credit was accorded to our little observatory came about by accident. It was well understood that a good determination of latitude by the zenith telescope method should not be in error more than one-tenth of a second of arc, or say about ten feet. But a study of all the observations made at the new observatory, as reported in the Annual Battalion Orders, indicated a slight but progressive change, as appears from the following figures quoted from the Battalion Order of February 15, 1886.

In 1880 (326 observations on 84 pairs) latitude	40°	47′	21″	.59
In 1881 (591 observations on 104 pairs) latitude	40	47	21	.47
In 1882 (235 observations on 60 pairs) latitude	40	47	21	.37
In 1883 (497 observations on 118 pairs) latitude	40	47	21	.15
In 1884 (523 observations on 89 pairs) latitude	40	47	20	.75
In 1885 (564 observations on 85 pairs) latitude	40	47	21	.49
Grand mean of 2,736 observations latitude	40	47	21	.29

This result seemed to me so surprising that I communicated the figures to some of my astronomical friends, and it so happened that one of them, Prof. Seth C. Chandler, was then engaged in studying some similar results reported from Europe. Full details of our records were given him at his request, and in his well known analysis of the problem he accorded gratifying recognition to the good work of our little observatory.

The frequency of auroral displays being well known to be connected with the occurrence of certain astronomical phenomena, advantage was taken of the unusual facilities at Willets Point to secure an accurate record of their number. The public property was guarded by three watchmen, especially selected for trustworthy character, who occupied three widely separated posts during the entire night. They were each ordered to report on the following morning whether any auroras had appeared, and if not whether the condition of the sky would have permitted any to be seen. The following is a summary (quoted from the Battalion Order of February 15, 1886), of these records for sixteen years, which is interesting in connection with the epochs of maximum and minimum solar spots as given by Prof. Fritz of Zurich, viz:

maximum, anno domini 1870.6; minimum, anno domini 1878. maximum, anno domini 1882.4. The average number of sun sp for the last nine of these years, as reported by Prof. D. P. Todd o the Lawrence Observatory in the monthly weather reports of the Sig- nal Service is added to the table. The "probable" auroras were es- mated by assuming the same ratio on the cloudy nights as was noted on the clear nights. For 1870 only the last eleven months were included in the table, all the other years being complete.

Summary for auroral records for sixteen years.

Years.	Clear sky.		Cloudy sky.		Total for year.	Average number of sun spots.	Remarks.
	Nights.	Observed auroras.	Nights.	Probable auroras.			
1870	184	50	150	41	99	———	11 months.
1871	211	60	154	44	104	———	
1872	234	60	132	34	94	———	
1873	214	54	151	38	92	———	
1874	190	18	175	17	35	———	
1875	189	14	176	13	27	———	
1876	195	9	171	8	17	———	
1877	191	7	174	6	13	2.6	Sun spot record be- gun June, 1877.
1878	185	2	180	2	4	2.2	
1879	204	9	161	7	16	2.0	
1880	216	13	150	9	22	14.3	
1881	191	23	174	21	44	26.7	
1882	201	55	164	44	99	28.3	
1883	215	24	150	17	41	27.4	
1884	180	12	186	12	24	38.0	
1885	208	11	157	8	19	50.8	

It will be noted, although there seems to be no correspondence between the above number of auroras and the number of sun spots as reported by Prof. Todd, that there is a remarkable correspondence between the auroras as observed at Willets Point and the epochs of maximum and minimum sun spots as reported by Prof. Fritz. It is certain that the heavens were carefully watched by our soldiers; indeed one of the watchmen, private Thomas Murphy of Company B, discovered and reported a new comet at 2h 20m A. M., on June 22, 1881, which was in advance of any other of the numerous claims reported by the newspapers.

TIDAL AND CURRENT MEASUREMENTS.

In 1871 a systematic course of practice in tidal current measurements with double floats, electric current meters, and a self-registering tide gauge to determine the hourly water level, was begun and continued annually under direction of the Battalion Adjutant or Quartermaster. Full records were kept and discussed by the observers.

MILITARY PHOTOGRAPHY.

The discovery that maps could be readily multiplied by photography was made shortly before the beginning of the Civil War, and the process was largely applied by officers of Engineers in the field, making use of civilian experts. Manifestly this work would pertain in future to the engineer troops, and the study was taken up in March, 1873, in an old building and with limited means. At first it was placed in charge of the Battalion Adjutant, Lieut. Mercur, and the instruction was confined to three non-commissioned officers from each of the three companies. In 1875 the building had beeen sufficiently enlarged to extend its benefits to the commissioned officers, and they were required to fit themselves for instructing their soldiers. Lieut. Quinn, Battalion Quartermaster, was in charge of the laboratory from December 1876, to April 1881, when it devolved on Lieut. Griffin as Battalion Quartermaster. Both of these officers did excellent service in developing this new branch of Engineer duty; the former contributed a paper on the subject to the Essayons Club series; and the latter to the Professional Papers of the School of Application. In this connection the long and excellent service of Sergeant Charles E. von Sothen of Company C should be remembered. Detailed as assistant to the officer in charge, about the time when the work began, and then having little or no knowledge of the subject, he devoted himself so enthusiastically to the study as ultimately to become an expert of no mean attainments. A paper written by him forms one of the School of Application Series.

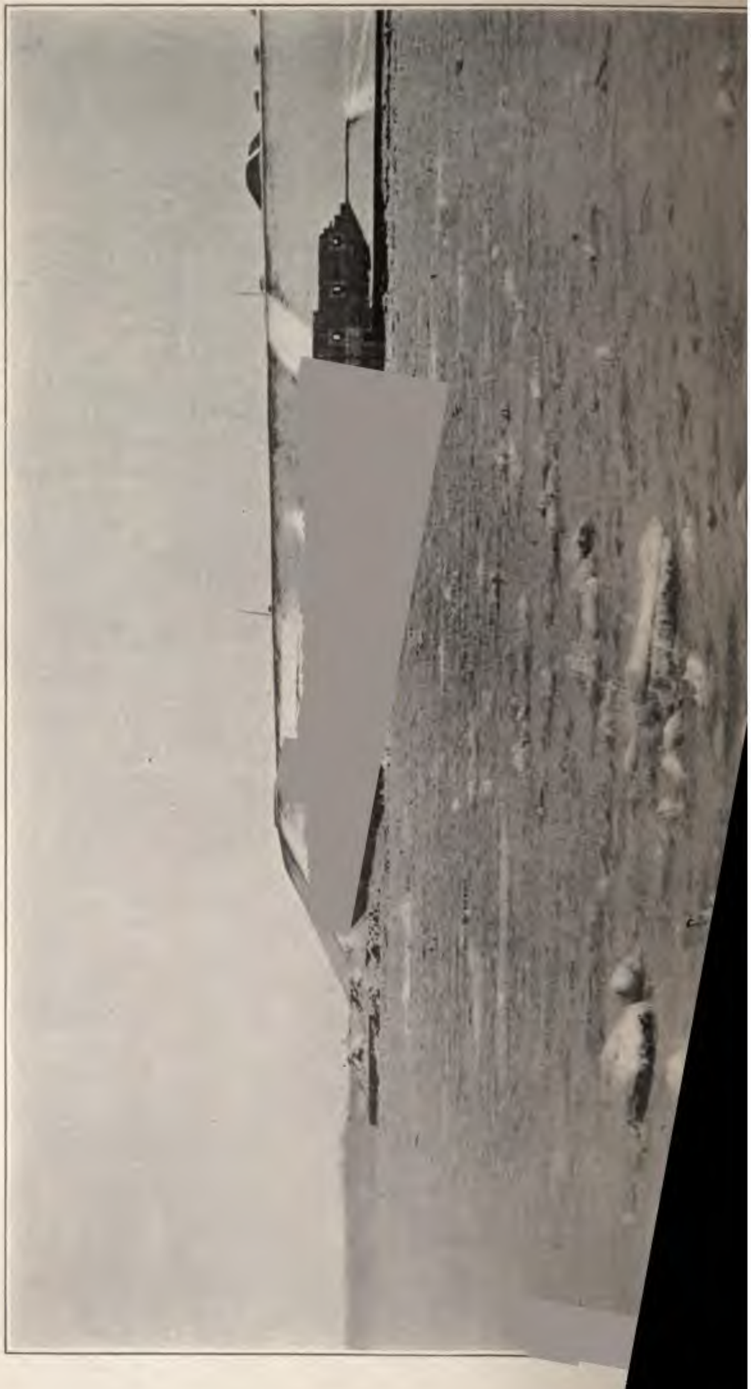
Finally, after long waiting, funds were secured and a really fine photographic laboratory was completed, and opened in November, 1882 After that date nothing more could be desired, either for the instruction of officers or the practical training of enough selected men in each Company to meet any probable demands of the service. As this subject was not included in the West Point course, officers were required to prepare and submit notes and to pass examinations in order to ensure their proficiency.

THE ENGINEER DEPOT.

The large collection of Engineer materiel at Willets Point was stored, guarded, and issued by the Battalion. The old buildings were all made of wood and were in close proximity to each other, as indeed was the case with the barracks and officers' quarters. The danger of fire was ever present. A large supply of water buckets, and copies of a map showing the location of all sources of water supply, were early prepared and distributed; fire drills were frequently had; an old hand engine formerly famous as "Tweed's Tiger" in the days of the volunteer fire organization of New York City was purchased in March, 1867, and the soldiers were exercised regularly in its use; finally the plan of special watchmen acting with more freedom than ordinary sentinels was established for posts distant from the Guard House. An event which happened on the occasion of the funeral of General George H. Thomas in April, 1870, illustrated the good judgment of one of the young officers, Lieut. Powell, Battalion Quartermaster. The troops were ordered to Troy to form part of the escort, and I left him in command of the Post, with only a few men to guard the property. Reflecting that the usual fire measures could not be carried out from want of men, the first thing he did was to have all available buckets filled with water, and to arrange a signal for all hands to assemble on the run. A few moments after these arrangements were perfected the cry of fire came from a building occupied as the Adjutant's office, situated on the line of officers' quarters. The stove pipe where it passed through the roof had ignited it. The signal was given; the men assembled, laughing at the supposed drill alarm; and the Post was saved from destruction, for the wind was strong and once started nothing could have stopped the flames.

In 1868-69 the Battalion did much experimental work for an Engineer Board appointed to prepare, in the form of a Ponton Manual, a revised system of bridge equipage and drill, which should embody the practical experience of the War. After its adoption, the manual work of remodeling many of the old wagons to make them conform to the adopted pattern was continued for several years by skilled carpenters from the Companies.

In 1870 the functions of the Depot were extended to include the inspection, repairs, and issue on approved requisitions of the instruments held in reserve for the use of the Corps. For their safe storage a fireproof brick building was finally erected. Some of them soon began to suffer from the condensation of moisture in the damp air of the seacoast, and an experiment on a large scale was made with calcium chloride (not chloride of lime) to artificially dry the room where the most delicate of them were stored. It had 37,000 cubic feet of air space. The crystals were exposed on gratings which allowed the fluid caused by the absorption of water to drip into reservoirs. This fluid was subsequently evaporated by boiling, and the



salt was thus recovered, to be used again. By noting the weight before and after boiling, the volume of water taken from the air of the room could easily be determined. During the year 1880-81 by six boilings each six hours long 74.7 gallons were thus removed: in 1881-82 seven boilings yielded 85 gallons; and in 1884-85 the volume was 107 gallons. The result was a decided success, and suggests how some damp powder magazines may be rendered dry at little expense.

THE SUBMARINE MINING SERVICE.

But the most important researches conducted at Willets Point during my tour of duty there were those connected with submarine mining. In May, 1869, General Humphreys, with the sanction of the Secretary of War, devolved upon the Battalion of Engineers the duty of developing a torpedo system, as an accessory to the permanent seacoast defences of the Country. The work was to be done under the direction of the Board of Engineers, of which the commanding officer was made a member when this subject was under consideration. The problem involved experimental researches with all known kinds of modern high explosives to determine their relative intensity of action, and the laws governing the transmission of the shock of explosion through water; the best form of cases, modes of anchorage, and typical grouping of mines to insure the blocking of a channel of approach; the best mode of operating the mines so that while innocuous to our own fleet they should be deadly to an enemy; in a word, an elaborate experimental study of a new and little known element of modern warfare. Work was immediately begun and continued without interruption during my entire tour of duty with the Battalion, resulting in developing a complete system which received the approval of the Government.

To determine the relative intensity of action of different explosives, and the laws of its transmission through water, use was made of wrought iron rings having interior diameters ranging from 3 feet to 8 feet, and carrying six pressure gauges disposed around a central charge to be tested. The method heretofore in use for forming the scales for these gauges by static compression proved to be inapplicable when they were subjected to the sudden blow given by a high explosive, and a new method by impact was devised which solved the difficulty. The rings were supported vertically at any desired depth by cylindrical buoys floating vertically, with pointed bottoms reducing the shock to the minimum. The whole apparatus was often thrown

bodily into the air with the jet. It was manipulated from a raft an
by connecting two pontons, and provided with a windlass for raising
and lowering the ring. To extend the measurements to longer ranges,
a large wrought iron crate, fifty feet by ten feet by ten feet, was con-
structed. The stresses were reduced to the minimum by making it
of half-inch plates from 5 to 11 inches in width, the planes of which
passed through the central point to be occupied by the explosive. Th
Each of the nine cross frames carried four pressure gauges. The
whole was supported, either horizontally or inclined at any desir
angle or depth, by two cylindrical buoys with wire rope slings
tached to cross frames diagonally braced. This apparatus was ma
vered by a sixty-ton schooner towed to the firing station by a
steam launch. Here the crate was abandoned to its buoys; the
was fired by electricity; the schooner returned; the crate was
and the pressure gauges were recovered. Many large charges
ent high explosives were fired in this manner, the last one, 10
of dynamite No. 1, fired in 1878, disrupted the crate, but t
were recovered. An analysis of these ring and crate recor
the algebraic law governing the transmission of intensity
through the fluid, together with the relative efficiency
dozen explosives, of which two, the safety compound
proved to be too dangerous for service. In 1879 dynamit
definitely adopted as the best known explosive for ou
mines. This conclusion was not reached without a long
periments upon sympathetic explosions, which demo
their range was too short for one explosion to endange
mines as planted for service; and also that, if not co
cartridges, the dynamite when thoroughly frozen was
detonated by our adopted fuze.

During the progress of the above experiments in
also been conducted to determine the intensity requir
bottom of a modern ship of war. A target represent
interior construction, 20 feet by 20 feet by 3 feet in
placed in position and held firmly down by several 1,
and chain cables crossed over it. Various charges of dy
ing up to 200 pounds, were supported under it at diff
ploded by electricity. These researches made know
and their dangerous ranges, whether floating or re

The formulæ resulting from these researches w
exceptionally cold winter of 1878-79 by many e

ice. The intensity at the edge of the circular crater produced by the explosion of a dynamite cartridge inserted through a small hole, was compared with those resulting from much larger charges at greater depths. The formulæ uniformly indicated like intensities at these points, thus confirming their trustworthy character.

In 1878 the old schooner that had been used to maneuver the crate was blown up, to illustrate the nature of the strains of a sub-aqueous explosion upon a vessel. Six cameras were employed to record the result. Their exposures were regulated by the explosion of electrical fuzes fired from a key board, the same circuit recording the exact time on a chronograph. The first view, taken at the instant when the mine exploded, shows the vessel lifted high amidships, with bow and stern depressed. This phase passed so rapidly that the eye failed to distinguish it. The maximum height of the water jet (180 feet) was reached in 2.3 seconds, showing the air full of fragments. In 4.3 seconds only a cloud of mist and smoke remained over the wreck. At this date the dry plate process had not been introduced and these highly successful pictures taken by the wet plate process reflect great credit on the photographic detail. Another sample of good photographic work was secured about this same date. A condemned mule was killed by exploding a cartridge of dynamite behind his ears. The exposure of the plate was caused by the explosion of a second fuze in the same electrical circuit. The picture showed the animal still standing, with his front legs slightly bent but with his head detached and hanging by a strip of skin against his breast.

The best kind of electrical fuzes for igniting the mines was determined by a long series of experimental investigations involving novel apparatus. Both high tension and low tension varieties were included.

The kind and shapes of torpedo cases and anchors received like attention, including resistance to blows from the largest class of steamers navigating Long Island Sound, moving at full speed, and actual submergence through a full period of five years. A knowledge of the degree of buoyancy necessary to prevent too much depression by strong currents was obtained at Hell Gate, in 1874, by a series of elaborate measurements, over 400 in number. A large scow was anchored bow and stern in 50 feet of water. Torpedoes of different shapes were held down by their anchors nearby. Graduated lines supported by fishing poles rose from their top rings, allowing the exact depression from the vertical to be noted at any instant. The velocity of the current, ranging at different stages of the tide from zero to five miles per hour, was measured by three independent methods and the corresponding depressions were read on the graduated lines. These data made known the constants of the desired depression formula. Such were the investigations which determined our adopted patterns of submarine mines.

At a later date a device was perfected by which either buoyant or ground mines, while quite safe to handle, would automatically become dangerous a few moments after submergence.

After trials of various experimental devices, the final patterns of circuit closers, batteries, testing apparatus, operating boxes, etc., were perfected, and a definite system for disposing the mines in grand groups or skirmish lines was adopted in 1874. The operating boxes included an arrangement by which the fire of guns previously pointed to sweep the lines of mines would be provoked at any locality by an attempt there at countermining. At this date 600 miles of torpedo cable and 300 mines had been procured; a new Torpedo Laboratory for officers and a building for the instruction of the enlisted men had been completed; a preliminary Manual had been issued in the form of a Battalion Order dated December 10, 1873; and the Board of Engineers had taken up the study of detailed projects for the defence of the harbors of the United States. In a word submarine mining passed at about this date from the field of investigation to that of practical application, in this country.

But it must by no means be inferred that researches in this direction were not actively continued. The Smith movable torpedo driven by ammoniacal gas and steered from the shore by electricity had early been the subject of practical trials at Willets Point. It was succeeded by the Sims fish torpedo, driven and steered by electricity from the shore, with which many elaborate trials were made involving accurate tracking by triangulation at intervals of a few seconds, and complete records of the power developed at the dynamo and expended at each point of the run. These trials called for the coöperation of nearly every officer at the Post, and of many of the enlisted men. Sufficient success was had to cause the purchase of a few of the torpedoes to place in store. At this date the electrical transmission of power was in its infancy, and few experiments in this country antedate these researches at Willets Point.

It is pleasant to remember that during these investigations the most cordial relations existed between ourselves and the Naval Torpedo School at Newport, then in charge of Commander E. O. Mathews.

Visits were often exchanged, and any new ideas were mutually communicated.

Experiments to develop the utility of electric light projectors for protecting mine-fields against countermining were conducted in the early days at Willets Point, when the use of this kind of light was so new as to attract many spectators. The first projector was a silvered parabolic reflector, served by from 50 to 200 Grove cells. Later an Alliance magneto-electric machine was used, and then a more modern dynamo, with a glass lens of the form used by the Light House Board but computed for the electric light. The conclusion was reached, in 1874, that this accessory in the defence of mine-fields is very useful in clear dark nights, of comparatively little value in bright moonlight nights, and of no value in fogs. Also that the observer must be at a considerable distance from the lens.

The proof edition of the Submarine Mining Manual was completed and printed on the Battalion press in 1877. This, after testing by practical use, was replaced by a new edition formally adopted by the Department, to which I put the last touches after being relieved from duty at Willets Point in 1886.

As the defence of the seacoast by submarine mines, assigned to the Corps of Engineers by Congress, involved study in several branches which hardly formed part of the curriculum at West Point, a new question was early presented as to the best mode of certainly making the young officers proficient in this duty. At first they were put upon a roster and detailed weekly by twos for such assistance as might be required, and to spend at least six hours daily in the laboratory, making use of the library and instruments for personal study of electricity, modern explosives, etc. No recitations or examinations were required. Finding from the examinations for promotion that in a few cases this plan was not entirely successful, a change was announced in the Instruction Order of November 9, 1882. The three Captains were constituted, under the Commanding officer, a Board of Instruction. They were individually to take military charge, for one week in turn, of the buildings and details of officers and enlisted men, and to direct the courses of reading, experiments and drills. The student officers were divided into two classes according to their periods of service with the troops. Semi-annual examinations before this Board (four for each officer) were prescribed; and a regular programme for each of them was laid down. This plan worked well, and it is believed was equally effective and less onerous for the officers than would have been recitations and marks. As this important Battalion Order, and indeed the entire series subsequent to July, 1879, are to be found in print in the Annual Reports of the Chief of Engineers, no further details are needed here.

It is a little singular, but is nevertheless a fact, that the establishment was officially recognized as a Torpedo School prior to its recognition as an Engineer School of Application. General Sherman, who often visited Willets Point and took great interest in the researches in submarine mining, issued the following order through the Adjutant General's Office on August 30, 1880.

"When the number of subaltern officers absent from any of the artillery regiments does not exceed eleven, the commanding officer of such regiment is authorized, with the approval of the department commander, to order one subaltern to Willets Point, New York, January 1st of each year, to serve six full months, to receive instruction in torpedo service."

Under this order a class of Artillery officers annually took the course in submarine mining under the conditions prescribed in Battalion Order of January 3, 1881, which gave them in all respects the same advantages as the Engineers. During my tour of duty these officers were:

Class of 1881—1st Lieut. E. L. Zalinski, 5th Artillery; 1st Lieut. J. E. Eastman, 2d Artillery; 1st Lieut. A. H. Merrill, 1st Artillery.

Class of 1882—1st Lieut. W. P. Edgerton, 2d Artillery; 2d Lieut. J. C. Bush, 5th Artillery.

Class of 1883—2d Lieut. J. L. Chamberlain, 1st Artillery; 2d Lieut. H. A. Schroeder, 4th Artillery; 2d Lieut. M. C. Richards, 2d Artillery.

Class of 1884—1st Lieut. I. T. Webster, 1st Artillery; 2d Lieut. W. P. Newcomb, 5th Artillery; 2d Lieut. O. M. Lissak, 4th Artillery; 2d Lieut. J. T. Thompson, 2d Artillery.

Class of 1885—1st Lieut. H. H. Ludlow, 3rd Artillery; 2d Lieut. C. P. Townsley, 4th Artillery; 2d Lieut. H. C. Carbaugh, 5th Artillery; 2d Lieut. S. Rodman, Jr., 1st Artillery.

Class of 1886—1st Lieut. Allyn Capron, 1st Artillery; 2d Lieut. C. G. Treat, 5th Artillery; 2d Lieut. I. N. Lewis, 2d Artillery.

Upon the completion of the course a report was made to the Commanding General of the Army, giving for each Artillery officer the opinion of the Board of Instructors as to his absolute fitness for detail in case of war, indicated under one of four grades, viz:

competent to plant and operate, competent to operate, competent as an assistant, or deficient. No classification as to relative proficiency was made in these reports.

For the instruction of the enlisted men in submarine mining, a systematic course was early inaugurated. At first an old carpenters' shop, subsequently replaced by a fine new building, was used as a laboratory for instruction in loading torpedoes, charging junction boxes, making joints in electric cables, operating the dial telegraph, and many other details of the service. During the summer season the soldiers were practiced in planting and raising mines; in firing them; in the boat service generally, making use for the latter of pontons, ponton rafts, a small steam launch, and finally of a fine new steamboat (for description see page 51, Annual Report of Chief of Engineers for 1886), designed specially for the purpose and named the David Bushnell, in memory of the pioneer in the use of sub-aqueous explosions for the destruction of shipping, who was a Captain of Engineers in the army of the Revolution. Instruction in this branch of the school was directed by the officers of the weekly torpedo detail, aided by sergeants who had become experts in the duty. Officers of that day will remember in this connection Sergt. Conklin, Sergt. Nolty, Sergt. Kelly, Sergt. Warner and Sergt. Brown.

SPECIAL RESEARCHES AT WILLETS POINT.

The first work of this kind was done in August, 1867. The introduction of armor and heavy guns on ships of war had raised many new questions as to the planning of works for coast defence. General Totten had always favored low sites, to secure the maximum advantages of ricochet fire. The new conditions suggested higher positions for the batteries, to be armed with 15-inch guns, and the problem arose to determine to what extent this involved a reduced length of ricochet trajectory dangerous to shipping. Observations to settle the question began on the Potomac in the summer of 1865, and were terminated by the officers of the Battalion in August, 1867, the firing being done for us by the artillery garrison at Fort Schuyler. The results in detail are given on pages 57-84 of No. 14, Professional Papers of the Corps of Engineers.

At the time when experiments with explosives was begun at Willets Point the use of low tension fuzes was not common in economic blasting in this country. The market was stocked with high tension varieties, ignited by a spark given by a class of machines of which that known by the name of the inventor, Mr. H. Julius Smith, was most common. The spark passing between terminals bedded in fulminating copper determined the explosion. The extreme sensitiveness, and hence the dangerous character of these fuzes, will be understood when it is stated that they could be ignited by passing an ebonite comb a few times through the hair of a child standing on an insulating stool, and holding one end of a leading wire the other end of which was attached to one terminal of the fuze, the other terminal being in the air. Accidents were common, and the matter demanded attention. An extremely delicate form of electrometer was devised by which sparks of known and regularly increasing quantity could be successively sent through the fuze until its detonation indicated the minimum necessary. By the aid of this machine and the coöperation of Mr. Browne, a fuze manufacturer, a reasonably safe priming, known later as Browne No.4, was discovered and used for a time in our experiments. He put it upon the market, and supplied large numbers to the Hoosac Tunnel, where it probably saved many lives. These researches are reported in detail in No. XLVII of the Essayons Club series. At this same time General Newton was conducting the preliminary operations for the great blast at Hallets Point, and narrowly escaping a terrible accident with one of the dangerous varieties, he took great interest in our researches at Willets Point, supplying me with samples of all his fuzes for test. This continued even after we had both of us adopted the low tension platinum wire fuze; and I was thus naturally led to study his special problem for the great blast, which demanded the firing simultaneously and with absolute certainty an immense number of fuzes. A paper giving the results of my analysis was read before the National Academy of Sciences on April 18, 1876, and it forms No. XXXIX of the Essayons Club series. General Newton used the formulæ in arranging his circuits for the great blast of September 24, 1876 (3680 fuzes), and again in that of Flood Rock in 1885 (591 fuzes), and with a success that left nothing to be desired. A conspicuous failure at a large private blast near Albany, a few months after the former, illustrated the importance of mathematical treatment in such problems.

General Humphreys, who always took interest in scientific investigations, appreciated the opportunity afforded by the explosion of about 50,000 pounds of dynamite at Hallets Point; and as General Newton had no facilities for measuring the velocity of transmission of the earth wave, assigned the duty to the Engineer Battalion. Delicate mercury seismometers were improvised at Willets Point, the

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coöperation of the Western Union Telegraph Company was secured, and the velocity was measured over a range of about 13 miles. Full details were read before the National Academy of Sciences on October 18, 1876, and may be found in No. XL of the Esasyons Club Papers.

The velocity of transmission proved to be about one mile per second, which so much exceeded that found many years before by Mr. Mallet from small gunpowder explosions in England that the investigation was continued at Willets Point, by taking advantage of the frequent firing of torpedoes ranging from 70 pounds of gunpowder to 400 pounds of dynamite. The results were published in the American Journal of Science for March, 1878. They suggested the following conclusions: "(1) A high magnifying power of telescope is essential with mercury seismometers. (2) The more violent the initial shock the higher is the velocity of transmission. (3) This velocity diminishes as the wave advances. (4) The movements of the earth's crust are complex, consisting of many short waves, first increasing and then diminishing in amplitude; and, with a detonating explosive the interval between the first wave and the maximum wave at any station is shorter than with a slow burning explosive."

At the much larger explosion at Flood Rock, on October 10, 1885,
the Battalion was charged with observations covering a wider range.
The exploding charge consisted of 240,399 pounds of rackarock, hav-
ing an intensity not inferior to that of dynamite No. 1, and of 48,537
ounds of the latter added to insure the full detonation of the former,
nd to reduce by sympathetic explosion the number of fuzes to be sim-
ltaneously fired. General Newton in his report states; "The speci-
ations required that the rackarock should have a strength only of 90
r cent that of No. 1 dynamite when fired under water and meas-
ed by the method in use at the Engineer School of Application at
illets Point. But such care was taken by the contractors in select-
their materials and such benefits derived from the careful deter-
ation made at Willets Point experimentally, and from the analysis
he exact proportions of oil and chlorate to be used, as well as the
oughness of the mixing of these ingredients, that the 71 samples
d showed an average strength of 109 per cent that of dynamite
1, no sample falling below 99 per cent."

the explosion the whole Battalion was on duty. Captain Bailey
charged with determining the exact instant of explosion, in 75
dian time, to render available time records of volunteer observers.
ain Knight experimented with three novel types of seismographs

set up at Astoria. Lieut. Lusk directed the taking of photographs at the firing point to determine whether the explosion was simultaneous in all the galleries. Three parties stationed along the telegraph line on Long Island and one at West Point received on their chronographs each tick of the standard break circuit chronometer at the firing station, and also when the mine was fired a signal made by the same motion of the firing key that caused the explosion. The local records of arrival and duration of the earth wave were also recorded on the same chronograph sheet. Thus the instant of explosion and the instants of arriving and ending of earth movements at each station were registered in the time of one standard chronometer. This plan was an improvement on that used at the Hallets Point explosion, by which only the interval of time between the igniting of the charge and the arrival and ending of the tremor at each station was registered on the chronographs. By adding the ticks of the standard chronometer provision was made for referring everything to the same absolute time, permitting comparison to be made with the records at several outlying stations, off the line of the telegraph, but where the true time was known from local astronomical observations. Such stations were Willets Point, Goat Island, and the observatories of Harvard College and Hamilton College, the latter extending the range of observation to a distance of about 175 miles from Flood Rock. At Willets Point not only was a mercury seismograph used but also as a check a Thompson reflecting galvanometer so adjusted as to be specially sensitive to local tremors.

My report to General Newton (page 691 of the Annual Report of the Chief of Engineers for 1886) fully covers the details of these investigations not only for the two great explosions but also for the similar special observations at Willets Point. It is therefore enough to state here that the earth wave at the Flood Rock explosion moved northward through rock at a velocity of nearly four miles per second, and eastward through the drift formation of Long Island at a more variable rate but nowhere exceeding about three miles per second. The Flood Rock charge was about six times as great, and the rate of transmission about three times as great, as those noted at the Hallets Point explosion.

MILITARY PEACE RECORD OF THE BATTALION.

On December 3, 1869, the Battalion was ordered with other troops to Brooklyn to support the Collector in suppressing some illicit distilleries near the Navy Yard. This duty was performed in a way to receive the official thanks of the Commissioner of Internal Revenue, communicated through the Department Commander.

Again, on November 3, 1870, the Battalion was ordered to Brooklyn on like duty.

In the same year the Battalion was ordered to New York City and, with other troops from the forts, was held in reserve to suppress anticipated election disturbances, which, however, did not occur.

In the great Railroad Riots of 1877 the Battalion took an active part, with all available regular troops. It proceeded to Baltimore on the night of July 1st, and while en route to relieve one of the regiments of the National Guard at its armory had a soldier in ranks knocked senseless by a brick thrown by a rioter. The incident had a ludicrous ending. The Battalion was marching in column of Companies, and Captain Livermore seeing his men likely to trample on the fallen soldier commanded "Halt" in so loud a tone that the entire Battalion obeyed the order. Marching at a right shoulder the men naturally came to a carry, and did it so perfectly in unison that the mob which crowded the street mistook it for the first movement of firing. A wild panic instantly occurred. Men rushed in every direction, one plunging head first through a window into a neighboring house. The street was effectually cleared, and we had no further annoyance in reaching the armory. On July 26th the Battalion was transferred to Philadelphia, and on August 2d to Easton, Pennsylvania, where it remained in camp until August 17tn, when it was ordered back to Willets Point. General Hancock officially commended its services in the following letter, signed by his A. A. Adjutant General:

"I am directed by the Major General Commanding the Division to say, that, orders having been issued relieving you from duty in the field, he takes the occasion to tender to you, and the officers and soldiers of your Battalion, his thanks for the soldierly manner in which all have preformed the arduous and delicate duties assigned them during the recent disorders. He further instructs me to say that the bearing and discipline of the Battalion have been admirable throughout, and that the services rendered by it deserve the highest commendation."

Such commendation from a soldier of General Hancock's record can hardly be appreciated too highly.

At the explosions at Hallets Point and Flood Rock the Battalion was called upon to preserve order and guard the public property, and it received the thanks of General Newton for the "prompt and efficient" manner in which it was done.

The Battalion formed part of the escort of regular troops at the funerals of General Thomas and of Admiral Farragut, and held the right of the line at that of General Meade, its old Commander whose Headquarters it had so often followed in the Civil War.

The Battalion took a prominent position in the regular service when the establishment of the rifle range at Creedmoor, in 1873, attracted general attention to this important element of military efficiency. The order of the War Department prescribing the system of instruction in markmanship laid down in Heth's Target Practice, and carried into effect by Battalion Order of March 23, 1867, had been scrupulously obeyed, and the men were already experts in shooting the rifle. The results of this practice, with the names and strings of the Company and Battalion prizemen, had been annually announced in orders since 1867. Indeed in 1869 the annual Army target prize. a large silver medal, had been awarded, it is believed for the first time, to private J. W. Miller of Company E. This prize had been open for competition to the entire army since 1862.

Individual and team practice at Creedmoor by our officers and men began soon after the opening of the range in 1873. In the first thirteen years, at the regular Spring and Fall Meetings, 117 individual prizes were won by them, using the Springfield rifle often in competition with sporting arms. Many team matches were also shot during this period, of which the following are the most noteworthy.

The Short Range Military Team Match.—Open to teams of five men duly certified to be members of the Company they represent in any organization of the National Guard of any State, or of the Regular Army, Navy, or Marine Corps. Distance 200 yards; position, standing; rounds, seven. The prize was a handsome embroidered flag, to be held by the winner for one year, and to become a permanent trophy after being won three times by the same organization. This was sharply contested for eight years, by about a dozen competitors. During this period it ornamented the barracks of Company B twice, of Company C twice, and in 1883 it became the permanent trophy of the latter.

The Army and Navy Journal Match.—Open to teams of twelve from all regularly organized military organizations in the United States. Their own uniform to be worn, and their own rifle to be used. Distance 500 yards; rounds, seven. This prize, too, was to be won three times before becoming the property of the winning organization. It was shot for ten times, and was sharply contested often by nearly

twenty teams. It was won in 1878 and again in 1881 by the Battalion, but was finally lost, in 1883, to the 7th Regiment of New Jersey National Guard, which had about 900 men to draw upon for its team while the Battalion had only about 150.

The Company Match.—Open to the National Guard and Regular Army. Teams of five men; distance 200 yards; match shot June 3, 1879; 8 competiting teams. Company C of the Battalion took 1st prize; Company B, 2d prize; and Company A, 3rd prize.

The Military Team Match.—Open to the National Guard and Regular Army. Teams of four men; distance 500 yards; match shot on same day as last; 6 competiting teams; two from the Battalion won 1st and 2d prizes.

The Skirmishers' Match.—This novel match was shot at the Fall Meeting in 1881. It was open to members of the Army, Navy, Marine Corps, and to the National Guard, Volunteers, or Militia of any country. Each competitor to advance from the 600 to the 200 yard range and return, making five halts in each passage. Twenty rounds were allowed to each man, and elaborate rules were prescribed for their use. Many soldiers competed, and the prize was won by private John Cavanagh of Company C. In transmitting it Major General Hancock, as President of the National Rifle Association, wrote to me:

"I send you herewith the 'Traver's Badge,' the first prize in the skirmishing match at Creedmoor—which was won by private John Cavanagh of your command.

"This match is one in which I take a special interest, as introducing a new departure in rifle matches. * * * It was my desire to show my appreciation of this match by presenting personally this badge at the close of the contest, but I regret I was unable to do so.

"I, therefore, transmit the badge to you with the request that you will present it to private Cavanagh, its winner, in front of his battalion, and in so doing convey to him and to his officers and comrades my congratulations upon his success, as well as the pleasure I feel in seeing that the Army is able to show that it can hold its own in practical military rifle shooting."

Under the competitions for the Nevada Trophy, prescribed in General Order No. 45 from the Headquarters of the Army, dated May 11, 1881, Company C of the Battalion took second place in 1881 and third place in 1882, the firing being open to all companies and batteries of the entire Army.

Under the provisions of General Order No. 53 Headquarters of the Army, series of 1882, establishing competitions for Department, Division and Army prizes for markmanship, the Battalion of Engineers had the distinguished honor of sending a marksman and alternate to report to the Commanding General of the Department of the Missouri to form part of the Army team of twelve soldiers selected by competition for the competition at Fort Leavenworth, in 1882. Sergt. Charles Barrett of Company B was selected to represent the Battalion, with Corporal Doyle of Company A as alternate, after careful competition at Willets Point. The match, at ranges of 200, 300 and 600 yards, was shot on October 25, 26, 27, 1882, and Sergt. Barrett won the first prize, a large gold medal, which he received from the hands of General Sherman. Thus did the Battalion a second time win the prize for markmanship open for competition to the entire army.

Sergt. Barrett was sent again in October, 1884 to compete at the bi-annual Fort Leavenworth match for the Army prize. There were twelve competitors and he won the fourth of the six prizes, a large silver medal presented in person by General Sherman. Shortly after, at a special prize match offered by the citizens of St. Louis to the six winners of the Army prizes, Sergt. Barrett won the first prize.

The foregoing military peace record of the Battalion makes it evident that, although much time and attention are given to matters forming no part of the training of other troops, the military efficiency of the soldiers is by no means impaired thereby. Neither officers nor enlisted men have ever failed when brought to this test.

END OF TENTATIVE DEVELOPMENT.

It will be appreciated from what has gone before that the development of the Engineer School of Application was a very gradual process. To furnish the officers with every possible facility for perfecting themselves in a knowledge of the practical duties of the Corps, had been kept steadily in view, and an advance had been made as rapidly as the means at hand would permit. A fairly good library had at last been secured; and a valuable collection of models illustrating bridges, ponton trains, military mining, river improvements, harbor improvements, and other engineering works had been accumulated, partly by utilizing the labor of skilled artisans in the Battalion, and partly by soliciting contributions in kind from officers of the Corps directing important public works. General Wright who had succeeded General Humphreys as Chief of Engineers, and whowas perfectly familiar with the conditions at Willets Point, considered at length that the time had come for a more formal recognition of the establishment, and early in 1884 he called upon me for a succinct statement of the conditions existing at the School of Application. The following letter was written in reply.

BATTALION OF ENGINEERS,
WILLETS POINT, WHITESTONE P. O.,
QUEENS COUNTY, NEW YORK,
February 6, 1884.

GENERAL H. G. WRIGHT,
CHIEF OF ENGINEERS, U. S. A.

GENERAL: In reply to your instructions of the 28th ult., I have the honor to submit the following statement of the course of practical and theoretical instruction adopted and now carried out at Willets Point, for graduates of the U. S. Military Academy assigned to the Corps of Engineers.

It is proper to premise that the School of Application, during the past 17 years, has gradually developed from an ordinary military Post to its present organization, and that progress has by no means ceased.

At the end of the War the Battalion of Engineers was ordered here from the field, to garrison and construct a new Post, and establish a depot for the bridge equipage and stores of Engineer material on hand. No permanent barracks or storehouses existed, and use was first made of the temporary buildings erected for the Grant General Hospital. The company officers of all grades had been graduated during the war and consequently had no experience in any of the civil duties of their Corps. At the outset every one was fully occupied in remodeling the buildings, in storing the material, and so far as time would permit in Engineer and Infantry drills. In a word, Willets Point differed in no essential particular from the other military Posts of the Army.

Shortly after his appointment as Chief of Engineers in 1866, General Humphreys inspected the establishment. He seemed to be impressed with three ideas: (1) That to command and properly instruct the companies a considerable detail of officers of the Corps would be permanently needed. (2) That this service should be apportioned among all the officers in turn, thus giving them that practical experience with troops which the war had convinced every one was desirable. And (3) that, for the young officers, the duty should be combined with facilities for supplementing theory, which time alone permits at West Point, with the practice needful to make the knowledge available in the actual works intrusted to the Corps of Engineers. For various reasons he did not consider it advisable to publish any general order on the subject; but in a personal conversation he instructed me under my own authority as Battalion Commander to require such professional exercises both civil and military as the facilities at hand would permit, informing me that, as a rule, the tour of duty for Captains and Battalion Staff officers would be about four years, and that immediately after graduation at the Military Academy the young officers would all be sent here for about two and a half years before assignment to other duty.

The general system thus inaugurated in 1866 has been carried out as closely as circumstances would permit up to the present time. Very little money has been available; but the steady support of the Chief of Engineers, and the interest and coöperation of the officers of the Battalion, have rendered it possible to overcome many difficulties; and, in my judgment, the School of Application now supplies a need of which every officer of the Corps was sensible before the war.

I shall not attempt to trace the gradual advance, which is sufficiently indicated by the file of Battalion Orders and by my annual reports. The following is the present status of the School.

The three Captains, in addition to the military command of their companies, are each charged with special branches of instruction, and, together with the Battalion Commander, constitute a permanent Board of Instructors. The Battalion Staff officers (usually 1st Lieutenants of several years' experience) also act as instructors in certain branches, in addition to their regular military duties. The recent graduates are attached to the companies, and beside the ordinary routine of a military Post, which is strictly enforced, enjoy many advantages for becoming familiar with various branches of civil and military engineering. The enlisted men are instructed both theoretically and practically by their Company officers.

The course is divided into two parts, winter extending from December 1st to April 30th, and summer covering the rest of the year. The first is chiefly in laboratories, and is somewhat theoretical in character; the last includes, also, exercises and practice out of doors.

By persistent effort the School has finally become well provided with apparatus. We now have a fine electrical and torpedo laboratory; a very convenient photographic laboratory; the best field astronomical observatory I have ever seen; a museum containing valuable models both military and civil; a new modeling room (now under construction to replace the old one) for moulding in sand on a scale of $\frac{1}{6}$ every kind of field fortification, including parallels and saps; a good range for target practice, with a room for gallery practice in the winter; an ample supply of surveying instruments, a self-registering tide gauge, current meters, &c.; and finally the nucleus of a professional library. So soon as practicable a small building will be erected for magnetic and meteorological observatories (the present one is not suitable), and a shed for practice with base measuring apparatus.

Perhaps the best way to explain the system of instruction is to indicate the duties of a young graduate from the time he joins the Battalion from West Point, until he has completed his first tour. (Most officers of the Corps return again as Captains and sometimes as Staff officers).

The new officers usually report from West Point early in October. The first two months are spent in becoming familiar with routine military duties, including practice with the sextant for regulating the Post time when officer of the day. These military duties of course continue during the whole period of service with the troops.

The first winter course (five months) includes 14 weeks of study in the Torpedo Laboratory, with two examinations before the Board of Instructors (January 31st and April 30); these examinations continue about five hours and cover the whole of the Torpedo Manual, in prescribed portions; 8 weeks of study and practical work in the Photographic Laboratory; two consecutive days of hourly meteorological observations, with the study of Colonel Williamson's report upon barometric hypsometry and the reduction of a part of the whole series (60 days' observations) made by the officers and non-commissioned officers; and lastly the conducting of some of the recitations of the non-commissioned officers of his Company, under the direction of the Captain.

The first summer course (7 months) includes frequent weekly details (fixed by number of officers for duty) for torpedo practice on the water and in the Labaratory, and for aiding the Battalion Commander in the investigations in submarine mining in progress; systematic instruction in practical astronomy, covering the use of the astronomical transit and zenith telescope, the sextant upon stars for time and latitude, and the personal equation machine—the extent of this work may be inferred from the fact that the observatory is in use on every pleasant night from May 1st to December 1st; the survey of one square mile of ground, including transit and stadia work and contours with the spirit level; the making of foot reconnaissances with pocket compass and hand level; and, under the direction of the Captain, the instruction of the enlisted men in Infantry drill, target practice, military reconnaissance, the use of the railroad transit, field fortification in the moulding room, ponton drill on land and on the water, and sometimes in military mining on land. The reduced force of the Battalion renders some of these drills unsatisfactory at present, and deprives the officers at well as the men of much valuable experience.

The second winter course includes 7 weeks in the Torpedo Laboratory, with two examinations before the Board of Instructors (January 30th and and April 29th); these examinations are each about five hours long, and cover the investigations in submarine mining made here during the past 15 years, and a study of all foreign systems and experiments so far as known; 8 weeks of study and practical work in the Photographic Laboratory, thus completing the course, which covers making negatives with gelatine emulsion plates, silver printing, map printing including glass and paper negatives, the blue process, etc., photo-lithography, heliotype process, &c.; two consecutive days of hourly meteorological observations and reductions, as before; and lastly aiding in conducting the Company recitations, as before.

The second summer course includes the frequent weekly details for torpedo practice, as before; instruction in practical astronomy completed, including the use of the latest patterns of combined transit and zenith telescope instruments, and of the 5.5 inch equatorial telescope; tertiary triangulation and hydrographic work, with current measurements and the use of the self-registering tide gauge; and the instruction of the enlisted men in their various drills and exercises, as before. So soon as the necessary buildings can be prepared, practice in field magnetic observations and in the use of the Repsold base apparatus will be included in this summer's work.

The third winter course includes 7 weeks in the Torpedo Laboratory, devoted to such reviews and investigations as the officer may select for himself, and in daily lectures and instruction to the enlisted men, under the Captain in charge—no examination is required; the meteorological observations as before; the preparation of drawings and a memoir upon some prescribed problem in permanent fortification or in the operations of an army in the field, which after revision and discussion by the Board of Instructors in the presence of the officer is transmitted to the Chief of Engineers; and finally the aiding in the Company recitations, as before.

The tour of the officer at Willets Point is supposed to terminate about May 1st, when the opening of the season creates a demand for assistants on the several works.

It may be added that in the fortifications at Fort Schuyler and Willets Point a fine opportunity is afforded to study in detail the development at all marked epochs during the past fifty years.

In conclusion, I would invite attention to three points, which in my judgment are of no little importance to the success of the School of Application. (1) The young officers should always complete their regular tours. (2) The Captains and Battalion Staff officers should be relieved by their successors before quitting the Post. They all occupy responsible positions which cannot be left vacant without more or less confusion. (3) The number of our enlisted men, as now authorized, is not only wholly inadequate to meet the needs of the Country should it become necessary to defend the coasts with torpedoes, or to put an army into the field, but is also insufficient for the preparatory instruction of both officers and men in their special military duties. The whole three Companies, recruited as they now are to only one-third of the organization fixed by law, cannot perform the ordinary guard and police duties of a Post like this and at the same time furnish enough men to properly construct a military bridge, to make a land mine or field fortification in any reasonable time, or even to permit of a satisfactory battalion drill.

Very respectfully, your obedient servant,

HENRY L. ABBOT,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

General Wright was retired from active service in March, 1884, before taking further action in regard to the School of Application. The Secretary of War, Hon. Robert T. Lincoln, visited the Post in July, 1884, in company with General Newton who had succeeded General Wright, and he was so much impressed with what he saw that he immediately authorized an increase of 250 men in the garrison, thus raising the effective strength of the Engineer Battalion from 200 men to 450 men. General Newton was also authorized to call upon the Board of Engineers for a report looking to a formal recognition of the School of Application by the War Department. The following document makes known the result.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY, WASHINGTON, D. C.,
February 20, 1885.

HON. ROBERT T. LINCOLN,
SECRETARY OF WAR.

SIR: I have the honor to submit herewith a report of the Board of Engineers for Fortifications, &c., upon the reorganization of the Engineer School of Application at Willets Point, made in compliance with instructions based upon your authority as granted in indorsement upon my letter of August 18, 1884.

In submitting this report I have to say that the first condition necessary to make the school at Willets Point efficient as a practical school of instruction for Engineer Officers is to insure its permanency.

BOARD OF VISITORS.

The Board of Engineers for Fortifications, &c., in New York, together with such other officers of the Corps of Engineers above the rank of Major as shall be stationed in New York City, should constitute a Board of Visitors, which should visit the school at least twice in each year and make a thorough and detailed inspection of everything connected with it, submitting a report thereof to the Secretary of War, through the Chief of Engineers, with such recommendations in reference to the school as may be deemed necessary.

ACADEMIC STAFF.

The Academic Staff of the School should consist of the Commanding Officer, *at least* one other field officer, and the Captains commanding the companies; the Adjutant of the Battalion of Engineers should be the secretary.

TOURS OF DUTY.

The tours of duty of the Commanding Officer and of the Field Officers detailed for the school should be as long as possible, subject to the exigencies of the service.

The regular tour of the *Captains* should not be less than three years, and only one of them should be relieved in any single year.

As the duty of instruction in some branches of the profession will probably devolve upon the Adjutant and Quartermaster, who should be First Lieutenants of high rank, the tour of each should be not less than three years, and only one of them should be relieved in any one year.

GRADUATES ASSIGNED TO THE CORPS OF ENGINEERS.

All graduates of the Military Academy who may be assigned to the Corps of Engineers, at the expiration of their graduating leave, should, as far as circumstances will permit, be ordered to the School of Application at Willets Point, and their tour of service should not be less than two and a half years.

LIBRARY.

Provision should be made from the appropriation for incidental expenses of the Engineer Depot at Willets Point for the annual purchase of a few new standard books for the library of the school.

INSTRUCTION OF ENLISTED MEN.

The enlisted men of the Battalion of Engineers should be instructed not only in their duties as soldiers of the line of the Army, but also in sapping, mining, pontoneering, the duties of a Torpedo Corps, &c.

The non-commissioned officers of the Battalion should receive theoretical as well as practical instruction.

REORGANIZATION OF THE ENGINEER SCHOOL OF APPLICATION.

The following plan of reorganization of the school, mainly a repetition of the ideas submitted in the report of the Board of Engineers, is recommended for approval.

The Establishment shall be designated *The Engineer School of Application of the Army of the United States.* It shall be divided into five departments, as follows:

Submarine Mining.—Including electricity, our own and foreign systems of defensive torpedo warfare, and modern high explosives.

Military Engineering.—Including the operations of armies in the field, seacoast defence, modern siege operations, and modern ordnance.

Military Photography.—Including all methods of map multiplication in the field and the use of the camera.

Practical Astronomy.—Including the best methods and the use of instruments employed upon the more important boundary surveys.

Civil Engineering.—Including practical surveying, river and harbor improvements, and barometric hypsometry.

OBJECT OF ESTABLISHMENT.

The object of the establishment should be to conduct researches in the branches of science applicable to the duties of the Corps of Engineers, to instruct newly assigned officers in the profession, and to train the enlisted men of the Battalion of Engineers to the highest possible degree of efficiency.

COMMAND.

The establishment, under the Chief of Engineers, should be under the military command of the officer of Engineers assigned to the command of the Post of Willets Point, N. Y.

ACADEMIC STAFF.

The Academic Staff should consist of the Commandant, of the other field officers of the school, and of the Captains commanding the Engineer companies stationed at Willets Point.

Any other officer charged with a department of instruction should be a member when his branch is under consideration. The Adjutant of the Battalion of Engineers should be secretary of the Academic Staff.

STUDENTS.

The students should consist of the subaltern officers serving with companies, of such other officers as may be authorized to study the course in whole or in part, and of the non-commissioned officers and privates of the Battalion of Engineers stationed at Willets Point.

EXAMINATIONS.

There should be two semi-annual examinations of the officers under instruction during the first and second years, and one during the last half year of their service with the Battalion. These examinations should be conducted by the Academic Staff in the presence of one or more members of the Board of Visitors. Careful records should be kept, which should be duly reported to the Chief of Engineers by the Commanding Officer of the Post.

These semi-annual examinations should take place on or about the end of January and on or about the end of April.

Their scope, subject to the approval of the Chief of Engineers, should be designated by the Commandant on the recommendation of the Academic Staff.

Officers of other arms of service attached to the school should be examined by the Academic Staff at such times as may be ordered by the Commandant, on the approval of the Chief of Engineers, and the results of such examinations should be reported, through the Chief of Engineers, to the General Commanding the Army when such officers are relieved from duty, or sooner if deemed expedient by the Academic Staff.

RESEARCHES.

The researches to be conducted at Willets Point shall be such *as may be approved by the Chief of Engineers.*

COURSE OF INSTRUCTION.

The annual course of instruction should be divided into two parts, winter and summer. The former, which will be chiefly library and laboratory work, should extend from about the first of December to about the end of April. The latter should include the rest of the year, and will be chiefly practical. So far as the season permits, theory and practice should at all times be combined.

During the summer season each member of the Academic Staff should be assigned by the Commandant to the charge of one of the departments of instruction, and so far as practicable this detail should be changed each year. In making such assignments, however, no Captain should be relieved of responsibilities which properly pertain to his military command.

During the winter season the supervision of the course should be divided among the Academic Staff.

The following should be the general programme of instruction, the details being ordered by the Commandant, upon the approval of the Chief of Engineers, upon the recommendation of the Academic Staff, which shall designate the necessary text books.

COURSE FOR OFFICERS.

The young officers should be required to assist in the various researches in military science conducted at Willets Point, with a view to familiarizing them with the methods employed in such work.

Their technical course of study should be arranged as far as practicable upon the following basis; details should be arranged by the Academic Staff:

	1st winter.	2d winter.	3d winter.
Submarine mining	14 weeks.	7 weeks.	6 weeks.
Chemistry and Military Photography	4 weeks.	4 weeks.	
Military Engineering		7 weeks.	3 weeks.
Civil Engineering			11 weeks.

During the summer much time will be occupied by the regular company duties, and it is not deemed possible to arrange the course as definitely as for winter. The following schedule indicates the general disposition of time:

	1st summer.	2d summer.
Submarine mining	7 weeks.	6 weeks.
Practical Astronomy	5 weeks.	6 weeks.
Military Engineering	Sapping, mining, and pontoniering drills, infantry drills and target practice, with their companies.	
Civil Engineering	4 weeks.	7 weeks.

COURSE FOR ENLISTED MEN.

The course of instruction for the enlisted men of Engineers should be determined by the Academic Staff, and should be repeated annually, more care and time being devoted to recruits than to instructed soldiers.

In submarine mining recruits should receive three months and instructed soldiers one month of drilling, covering seven hours daily. These drills should include all the duties of the loading room, boat service, and the handling and firing of modern high explosives. Grand groups of mines should frequently be planted and raised, and the entire familiarity with the service which practice alone can give should be insisted upon.

In field fortification and sapping each company should have one months' regular practice in the moulding room, and such outside work as may be found practicable.

In pontoniering each company should have two months' regular practice, arranged to include every part of the authorized manual. In military mining on land each company should have one months' practice, including the construction and firing of mines charged with gunpowder and modern high explosives. In Infantry drill and target practice each company should be exercised enough to maintain the reputation already acquired by the Battalion in this necessary part of its duty.

In foot reconnaissance and military map making all the non-commissioned officers and many selected privates should be thoroughly instructed. In military photography and the multiplication of maps in the field all the non-commissioned officers should receive regular instruction, which for men of special aptitude should be sufficiently extended to provide each company with skilled artisans to perform this work in war.

The practice in simple reconnoitering and surveying, and in the use of the barometer already carried out should be continued not only for its own utility, but also to train the men in intelligence and in manual dexterity in the use of instruments which their field duties often demand.

As the object of this organization is to obtain a complete system of instruction, it is suggested that if the foregoing meet with approval, that such approval be given with the understanding that changes may be made from time to time by the Chief of Engineers, with the approval of the Secretary of War.

I have also the honor to recommend that there be prepared at Willets Point, under the direction of the Board of Engineers, a torpedo manual, which will present the practical method of loading and anchoring torpedoes, making all electrical connections, and firing both single mines and groups; this manual should give concise description of all boats and machinery for planting torpedoes with expedition, and the whole subject of the torpedo system should be condensed in a course of instruction similar in scope to the drill for pontoniers.

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The object of this manual is, without betraying anything which in the judgment of the Chief of Engineers it is important to keep secret, that officers and even intelligent non-commissioned officers who have been

through the school of instruction, may be enabled to plant torpedoes both singly and in groups, and to manipulate them efficiently and skillfully.

In connection with the researches at Willets Point, the Commandant should from time to time inform the Board of Engineers for Fortifications, through the Chief of Engineers, of every new discovery or invention of this character, in order that the Board may be able to use such information in preparing the system of defence for various harbors throughout the United States.

I am, sir, very respectfully, your obedient servant,

JOHN NEWTON,
Chief of Engineers, Brig. and Bvt. Maj. Gen., U. S. A.

1st Indorsement, War Department, February 28, 1885.

Approved: ROBERT T. LINCOLN,
Secretary of War.

It seems fitting that this record of the early days of the Engineer School of Application should be brought to a close at the date of its formal recognition by the War Department. I remained in command about a year longer, but as will be seen by comparing the approved document with my letter above there was no radical change in the establishment. There were no recitations and no published marks, or standings. The school had attained its growth naturally, seeking to assist and not to drive officers in preparing for their life work. Such had been the basis of General Humphreys' original plan and instructions.

It only remains to name the Captains and Battalion staff officers who, as the instructors at Willets Point, had one and all most cordially and efficiently assisted in the work. They were in order of assignment: Captains Harwood, Howell, Holgate, Burnham, Mansfield, Ernst, Mackenzie, King, Raymond, Twining, Livermore, Cuyler, Mercur, Miller, Handbury, Gregory, Mallery, Ruffner, Price, Palfrey, Mahan, Bailey and Knight. Battalion Adjutants; Lieutants A. N. Lee, Maguire, Hinman, Heuer, Mercur, Bass, Leach, Greene, Quinn, Mallery, Fisk, Griffin, Willard, Bixby, Millis, Hodges, Warren, Crosby and Roessler. Battalion Quartermasters; Lieutenants Heap, Chase, Powell, Davis, Payson, Greene, Taber, Quinn, Griffin and Lusk. My association with these officers, and with the nearly fifty young students who have since so worthily maintained the reputation of the Corps, will always form one of my most pleasant memories.

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U.S. ENGINEER SCHOOL,
UNITED STATES ARMY.

IMPRESSIONS *of* A COMPANY COMMANDER

By
LE CAPITAINE BREVETÉ DU GÉNIE POTEZ

Translated from *Revue du Genie Militaire*, July-August, 1901, by
CAPTAIN J. R. WILLIAMS
Artillery Corps, U. S. Army
CAPTAIN F. R. SHUNK
Corps of Engineers, U. S. Army
1ST LIEUT. E. M. RHETT
Corps of Engineers, U. S. Army

REVISED EDITION

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~~No. 6.~~

U.S.

OCCASIONAL PAPERS,
ENGINEER SCHOOL OF APPLICATION,
UNITED STATES ARMY.

HISTORICAL SKETCH

OF THE

FIRST BATTALION OF ENGINEERS

DURING ITS TOUR ABROAD.

SMITH S. LEACH,
MAJOR, CORPS OF ENGINEERS, U. S. ARMY, COMMANDING.

PRESS OF THE ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.
—1903—

H

F ENGINEERS

OUR ABROAD.

S. LEACH,

INEERS, U. S. ARMY, COMMANDING.

HE ENGINEER SCHOOL OF APPLICATION,
ON BARRACKS, WASHINGTON, D. C.
—1903—

No 7,

OCCASIONAL PAPERS,
ENGINEER SCHOOL OF APPLICATION,
UNITED STATES ARMY.

HISTORICAL SKETCH

OF THE

FIRST BATTALION OF ENGINEERS

DURING ITS TOUR ABROAD.

SMITH S. LEACH,
MAJOR, CORPS OF ENGINEERS, U. S. ARMY, COMMANDING.

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HDQRS. 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANS.,
June 9, 1903.

THE ADJUTANT GENERAL, U. S. ARMY,
Washington, D. C.
(*Through Military Channels.*)

SIR: In compliance with instructions contained in letter from the Adjutant General's office of November 11, 1902, I have the honor to submit herewith an historical sketch of the operations of the 1st Battalion of Engineers.

This battalion was organized in May and June, 1901, from Companies A, B, and E (old) Battalion of Engineers. On account of this fact and of the nature of the service performed by the companies of this battalion subsequent to its formation, which service required that all companies be detached from battalion headquarters, it is thought that it will be more advisable to submit a brief account of the formation of the battalion, and submit a sketch for each company separately. This method is followed in the paper herewith.

Very respectfully,

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

1st Indorsement.

HDQRS. 1ST BATTALION OF ENGINEERS,
FORT LEAVENWORTH, KANS.,
June 9, 1903.

Copy respectfully furnished to the Chief of Engineers, U. S. Army.

SMITH S. LEACH,
Major, Corps of Engineers,
Commanding 1st Battalion of Engineers.

2d Indorsement.

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
June 26, 1903.

1. Respectfully referred to Major Edward Burr, Corps of Engineers.

2. In the opinion of the Chief of Engineers, this well-written and authentic history of the foreign service of the 1st Battalion of Engineers is well worth printing.

* * * * * * *

BY COMMAND OF BRIGADIER GENERAL GILLESPIE:

FREDERIC V. ABBOTT,
Major, Corps of Engineers.

HISTORICAL SKETCH OF THE 1ST BATTALION OF ENGINEERS DURING ITS TOUR ABROAD.

The organization of this battalion was effected under authority of G. O. 22, Headquarters of the Army, A. G. O., Washington, February 26, 1901, Major Clinton B. Sears, Corps of Engineers, being assigned to command by G. O. 79, Division of the Philippines, Manila, April 26, 1901. The former orders prescribed that the 1st Battalion of Engineers should consist of four companies, designated as Companies A, B, C, and D, and that it should be formed from the three companies of engineers, A, B, and E, then on duty in the Philippines, a new company to be formed by transfers from the three existing companies and the designation of Company E to be changed to Company C. Officers were assigned to companies of the battalion by S. O. 55, Headquarters of the Army, A. G. O., Washington, March 8, 1901.

Major Sears assumed command of the battalion on May 16, 1901, and appointed the following staff and non-commissioned staff:

Adjutant, 1st Lieutenant Harry Burgess, Corps of Engineers; Quartermaster and Commissary, 1st Lieutenant Sherwood A. Cheney, Corps of Engineers; Sergeant Major, Truman Organ, Company E; Quartermaster Sergeant, William Harer, Company E.

The Adjutant and Sergeant Major reported for duty as such on May 30, 1901; the Quartermaster and Commissary on September 28, 1901, and the Quartermaster Sergeant on June 18, 1901.

The battalion headquarters (the Battalion Commander, Adjutant, and Sergeant Major only) was established at Santa Lucia Building, Malacon Drive, Manila, and remained there until October 2, 1901.

On July 20, 1901, Company A, under command of Captain W. E. Craighill, sailed for the United States.

On October 1, 1901, Captain George A. Zinn took command of the battalion, Major Clinton B. Sears being relieved by Paragraph 1, S. O.

248, Headquarters Division of the Philippines, Manila, P. I., September 20, 1901. Headquarters of the battalion was established in Cuartel de Malate, October 2, 1901, and remained there until the battalion went aboard transport to return to the United States.

On October 18, 1901, the battalion, consisting of battalion headquarters and 3 companies (4 officers and 234 enlisted men), sailed for United States on transport *McClellan*, arriving at New York City, December 23, 1901. Battalion headquarters and Companies B and D proceeded to Jefferson Barracks for station; Company C, to West Point, N. Y.; Company A, upon its arrival in the United States, was assigned to duty first at Willets Point, N.Y., and subsequently, on September 3, 1901, at Fort Leavenworth, Kans.

Officers on duty at battalion headquarters: Major Clinton B. Sears, Corps of Engineers, May 16, 1901, to October 1, 1901; 1st Lieutenant Harry Burgess, Corps of Engineers, from May 30, 1901; 1st Lieutenant S. A. Cheney, Corps of Engineers, from September 28, 1901; Captain George A. Zinn, Corps of Engineers, October 1, 1901, to January 18, 1902 (in addition to his duty as Commanding Officer, Company B.)

Detailed history of companies follows:

COMPANY A.

Company A, consisting of one 1st Lieutenant, one additional Second Lieutenant, and 60 enlisted men, left Willets Point, N.Y., for San Francisco, Cal., on May 24, 1898, 1st Lieutenant C. P. Echols, Corps of Engineers, in command. The company arrived at San Francisco and went into camp at Camp Merritt, May 29, and was assigned to the 1st Brigade Philippine Expeditionary Forces, under command of Brigadier General Miller.

Captain W. C. Langfitt, Corps of Engineers, arrived and took command of the company June 2, and remained with the company until June 20, when he was relieved, having been appointed Major of Volunteer Engineers. Enlistment to war strength (146) was authorized and recruiting office established in San Francisco on June 8, and the enlisted strength of the company increased to 122. Additional 2d Lieutenant R. D. Kerr, Corps of Engineers, joined the company June 18. On June 14, a detachment of 20 men, commanded by 2d Lieutenant W. D. Connor, Corps of Engineers, left San Francisco for Manila on steamer *China* and arrived in Manila Bay July 16, landed at Cavite Arsenal the following day and remained there until July 29, when it moved to Camp Dewey, near Manila, where it remained until joined by the company.

The company with present strength of one 1st Lieutenant, one addiditional 2d Lieutenant, and 100 enlisted men, left Camp Merritt June 26 to join third expedition to the Philippines under command of Brigadier General MacArthur, and embarked on the *Indiana* same date, sailed on June 27, arrived at Honolulu July 6, and sailed for Manila July 8, where it arrived July 31. Additional 2d Lieutenant R. D. Kerr died July 21, and was buried at sea July 22, latitude 20° 48′ north, longitude 15° 18′ east. During most of the voyage daily drills were held, viz, signal, calisthenics, and theoretical engineering.

The company landed at Cavite Arsenal August 1, and went into temporary quarters until August 7, when it was ordered to Camp Dewey, where it remained until August 13. During the absence of its own officers from August 2 to August 6, 2d Lieutenant P. H. Mullay, 14th Infantry, had command of the company. While in Camp Dewey the company constructed a portable trestle bridge 180 feet long, which was carried to the front on August 13, but was not needed as the permanent bridges were not destroyed.

On August 13 the company was divided into two platoons, the first, commanded by Lieutenant Connor, reported to General Greene on the left, and the second, commanded by 1st Sergeant James Reardon, reported to General MacArthur, and both platoons entered the city of Manila with the first troops, the first platoon being quartered in the Insular Tobacco Factory at Binondo, Manila, and the second in the Cuartel de Malate, at Malate, Manila. Lieutenant Echols, who had been in hospital at Cavite since the company arrived in the Philippines, joined the company on the evening of the 13th, and on the 14th the second platoon joined the first at the Insular Tobacco Factory, where the company remained until December 29, when it moved to quarters in the Convent de Malate, Manila.

In August, a reconnoissance of the battlefield was made and a map prepared. A detachment of Sergeant Thomas F. Kennedy and 26 other enlisted men was engaged in clearing the Pasig River for navigation (under Ensign W. A. Moffitt, U. S. Navy), from August 28 to October 31.

Lieutenant Connor was relieved August 23 from duty with the company per S. O. 33, Headquarters Department of the Pacific, series 1898.

During the period from August 14, 1898, to February 4, 1899, the company was employed in making a detailed reconnoissance of Manila and vicinity. Sergeant Fisher with a detail of four privates from the company, while on reconnoissance duty near the insurgent's lines, were captured by them on January 29, 1899, and taken to Malolos where they were confined until February 3, when they were released and permitted to join the company.

September 3 and 4, 1898, no officer was present for duty with the company.

September 5 to 7, the company was commanded by 1st Lieutenant

M. G. Krayenbuhl, 3d Artillery.

From September 8, 1898, to March 5, 1899, the company was commanded by 1st Lieutenant W. G. Haan, 3d Artillery.

The company was assigned to the 2d Division, per G. O. 17, Headquarters Department of the Pacific and 8th Army Corps, series 1898.

Lieutenant Echols was relieved from duty with the company November 11, 1898, per S. O. 104, Department of the Pacific and 8th Army Corps.

On February 5, 1899, the company, commanded by Lieutenant Haan, took part in the attack on the insurgents, moving out on the right flank of General King's brigade, of the 1st Division, starting from Blockhouse No. 12, about 8:20 A. M., and took possession of the heights beyond San Pedro Macati at 10:10 A. M., and occupied the town at 11 A. M.

During this attack and while advancing, Colonel Smith, one Lieutenant, and 13 enlisted men of the 1st California Infantry joined the company, they having been cut off from their command, which arrived at San Pedro Macati about 45 minutes after the company had taken possession. Colonel Smith's regiment having arrived our outposts were relieved and the company returned to its quarters.

On February 15 the company, having been directed to make a reconnoissance outside the lines, became a part of an attacking force of the companies at Pateros; the company had the right of the line. Artillery was at first used and the order was to advance immediately after. The company advanced in the firing line, having a support of three companies. The insurgents were discovered and attacked, and for two hours kept under fire, but no support came to the assistance of the company and as there was no other firing, the company was withdrawn. It was afterward learned that the order to retire had been given just as the company had advanced and it was consequently left alone in the attack, but it had such a strong position that at no time did the insurgents show themselves without getting such a fire that they were compelled to withdraw to cover.

In February a detachment surveyed the country from Manila to San Pedro Macati, and the road from there to Pasig.

2d Lieutenant W. P. Wooten, Corps of Engineers, joined the company February 27, per S. O. 293, A. G. O., December 13, 1898.

Captain F. R. Shunk, Corps of Engineers, joined the company February 27, per S. O. 267, A. G. O., November 11, 1898.

On March 28 Captain Shunk, with a detachment of 25 enlisted men, joined General MacArthur's division in the northern advance. The detachment was employed in repairing roads and bridges destroyed by the retreating insurgents; constructing rafts, rope ferries, ponton bridges, and building new bridges according to the kind and amount of material that could be obtained, and in reconnoissance work. This work was performed chiefly in the night, as it was essential that the ammunition and supply trains be kept in touch with the firing line. During the day and when not engaged in engineer work the detachment participated in several engagements, and on several occasions at night it passed beyond the outposts to reconnoiter and to repair the railroad to enable the armored cars to keep up with the firing line. During this period the advance was rapid until Malolos was reached.

From the latter part of March Lieutenant Wooten, with a detachment of 25 men from the company, also took part in the same advance under the immediate orders of General Wheaton. The work done by this detachment was similar in character and extent to that outlined above for Captain Shunk's detachment.

Upon arrival at Malolos, Captain Shunk was ordered to return with his detachment to take station again in Manila—at Malate Convent.

The other detachment continued with the northern advance. The first serious delay was encountered three miles north of Malolos, where a steel railroad bridge spanning the Bag Bag River had been destroyed, one 80-foot span having been detached and dropped a distance of thrity feet into the river. Not having facilities to raise the span, the break was crossed by the construction of a substantial trestle bridge. The next difficulty was encountered at Calumpit where the truss railroad bridge across the Rio Grande de la Pampanga had been rendered useless by the insurgents by removing the fish plates, throwing into the river the rails, burning the ties and removing the roadway bearers. Want of proper facilities and necessity for prompt passage of this river rendered impossible the repair of this bridge at that time, and a rope ferry was constructed; one detail cut down approaches, another stretched the line, another procured material, and the remainder constructed the raft, which consisted of four layers of bamboo, the pieces of adjacent layers at right angles, the whole well lashed, and 35 feet wide and 48 feet long and having a safe carrying capacity of 10,000 pounds. The first load of artillery pieces was transported across the river within three hours from the time of setting about the construction of the raft. The width of the river here is about 650 feet and the river is about 20 feet deep.

A similar condition was found in May between Apalit and Santo Tomas, where a steel railroad bridge had been destroyed by dropping one end of a span into the Santo Tomas River. The span was replaced by the construction of a substantial bridge, the trestles resting on the inclined truss as it lay, the dropped end resting on a secure foundation.

2d Lieutenant H. W. Stickle, Corps of Engineers, joined the company April 23.

During the month of May, in addition to the Santo Tomas bridge repairs, the detachment, under Lieutenant Wooten, accomplished the following work:

1. Building wagon bridges between Calumpit and San Fernando via Apalit, and repairing wagon road. Two bridges about 100 feet each were built entire out of lumber obtained mostly from the church and convent of Apalit. The detachment had no transportation and hauled material on impressed bull carts. This road was for about three weeks the only supply line between Calumpit and San Fernando.

2. The rope ferry at Calumpit was kept in working order.

3. Nearly two miles of railroad track had been destroyed between Santo Tomas and Calumpit, and the roadbed much torn up in the construction of earthworks. By May 20 the road was opened and flat cars pushed by coolies were then used to bring supplies until other rolling stock could be secured. All the other rolling stock at that time was either south of the Rio Grande or in possession of the insurgents north of San Fernando, the railroad bridge at Calumpit being impassable for trains.

Having arrived in San Fernando the advance was halted for reinforcements, and to allow the men to recuperate as they had been under constant fire for about three months. During the stay in San Fernando the insurgents made several night attacks, but in each case were repulsed with severe loss.

On June 10 and 11 Lieutenant Stickle accompanied General Wheaton in General Lawton's advance against insurgents at Las Pinas and Paranaque. June 14–19 a detail of 27 enlisted men under Lieutenant Stickle constructed a temporary bamboo bridge at Paranaque over a stream about 300 feet wide. During this time the Zapote River bridge, damaged by fire by the insurgents, was repaired.

June 20–July 15, a detail of nine enlisted men under Lieutenant Stickle built a trail bridge for use across the Bag Bag River at Quingua, 25 Chinese laborers and about the same number of natives being hired to construct the approaches, which were made from high steep banks. The raft was of catamaran form, both boats and flooring being made completely by the detail, and mostly of native lumber. The raft was 30 feet by 16 feet when completed. The width of the stream was about 200 yards and the distance between anchorages about 250 yards. The cable used was one inch of steel and was raised and lowered by shears on each bank and made taut by an improvised field capstan on one bank, the shears finding use particularly in the frequent cases of sudden rising of the river at this point, due to heavy showers in the mountains a few miles distant where this stream had its source.

During August a detail of eight enlisted men under Lieutenant Stickle built a rope ferry for the river at Paranaque, the temporary bridge having been washed away. This raft was built in catamaran fashion on two cascos hired for the purpose. In August, also, the cable at Quingua having broken, the same detail put in a new cable. The service rendered by Private Duncan C. Morrison in stretching this cable was hazardous and was skillfully performed.

In addition to its engineering duties the detachment under Lieutenant Wooten was assigned to the armored car during the advance from San Fernando to Calulut and during the battle and capture of the latter place on August 9, 1899, occupied the center of the line.

During August and September the company was very much scattered, being divided into small details for various emergency work in the Island of Luzon. This included the construction of a bridge by a detail under the supervision of Captain Shunk at Imus. This was a high trestle bridge about 75 feet long and built of lumber shipped by water from Manila. In the latter part of September the company was ordered to occupy part of the line from Pasay to San Pedro Macati. It was assigned a position at Culi Culi, near the center of the line, which it held for about forty-eight hours, acting as infantry, Captain Shunk commanding.

From October 2 to 31 a number of enlisted men of Company B, varying from 30 to 61, were attached to Company A.

On October 4 the company, with a detachment of Company B, Captain Shunk commanding, was directed to take up a position and form part of a battalion with two companies of infantry at Paranaque ferry and connect with the infantry at Pasay, this being a line of about four miles for three companies to hold. This duty was performed by patrolling and continued three days. In the meantime the ferry and its approaches were put in good order.

October 7–14 the company took part in General Schwan's expedition in Cavite, under Captain Shunk, October 7, and Lieutenant Stickle the remainder of the time. The operations of the company during this time may be outlined as follows:

1. Construction of rope ferry across Bacoor River during the night of October 7, and manning boats for crossing the infantry.

2. The repair of roads for the main column from the Bacoor River to Dasmarinas October 8 to 12.

3. The work of a detachment of the company under Lieutenant Stickle in the column under Major Bubb, from Rosario to San Francisco de Malabon on the left bank of the Canas River October 9 to 11, consisting of:

a. Construction of raft for artillery and wagons and manning boats for infantry to cross the Canas River near Rosario.

b. Repairing of roads and trails left bank of river.

c. Engagement with the enemy in which one private was wounded, near Santa Cruz de Malabon.

d. Reconnoissance and scouting duty.

4. Reconnoissance from San Francisco de Malabon to San Gaviel October 11, and from Dasmarinas toward Silang October 12.

On October 16 the detachment under Lieutenant Wooten took part in repelling a night attack on Angeles and constructed emplacements for artillery near the Angeles bridge. This detachment was at this time continually engaged in foot reconnoissance, repairing railroads, wagon roads, and bridges. During the month of October small squads of non-commissioned officers and privates of the company were at different periods in charge of squads of Chinese laborers constructing and repairing various roads in the vicinity of Manila.

In October the company received instruction in foot reconnoissance and had some infantry drills.

1st Lieutenant S. A. Cheney, Corps of Engineers, joined the company November 3, per S. O. 302, Headquarters Department of the Pacific and 8th Army Corps, series 1899, and continued on duty with the company until relieved December 24, 1899, per S. O. 352, same headquarters and series.

A detachment of 2 officers and 25 enlisted men under Lieutenant Cheney, accompanied General Wheaton's advance by water on San Fabian on November 4, 1899. The work of this detachment was continuous and arduous, and exposure to inclement weather severe. It consisted in unloading mules and horses from transports anchored about a mile from shore, unloading supplies on the beach, repair of roads, building of a bamboo raft and its use in a rope ferry across the San Fabian River, the repair of telegraph and telephone lines from San Fabian to Tayug and participation in the firing line.

Lieutenant Cheney accompanied the expedition of the 13th Infantry to the north of San Fabian in November and took part in an engagement south of Santo Tomas. Lieutenant Stickle of this detachment accompanied one company of the 36th Infantry as engineer officer on an expedition to Salasa, and took part with that company in the attack on and capture of the town of Mangatarem in the latter part of November.

Lieutenant Stickle was relieved from duty with this detachment December 1 and returned to Manila.

On November 5 Lieutenant Wooten's detachment took part in the battle of Magalang, and from there went to Mabalacat and constructed a trestle bridge to replace an arch bridge which had been blown out by the insurgents. On November 11 this detachment took part in the battle of Bambam, after which it joined General Wheeler's column in the advance on Tarlac, November 12–14, repairing or constructing bridges injured or destroyed by insurgents. In November this detachment repaired about two miles of Manila & Dagupan Railroad which had been completely washed away by the Tarlac River; 800 feet of trestle was constructed of crib-work which was afterward used by the Manila & Dagupan Railroad. for over a year, the work being accomplished in ten days and going on night and day. About November 24 this detachment moved to Calasiao and commenced the construction of the railroad from that point to Dagupan, this portion, about two miles, having been completely destroyed. Some rolling stock which had been run off into the Calasiao River was recovered. In this work the detachment was assisted by a detachment from Company B, under Lieutenant H. B. Ferguson, Corps of Engineers.

Lieutenant Cheney's detachment returned from San Fabian to Manila and joined the company about December 20.

Lieutenant Stickle accompanied a detachment of Company B under Lieutenant J. C. Oakes, Corps of Engineers, from December 17 to December 30, repairing ferries and bridges from Arayat to Cabanatuan via San Isidro and returned to Manila.

Lieutenant Wooten was relieved from duty with the detachment and joined the company the latter part of December, leaving the detachment at Bayambang.

Companies A and B were united January 1, 1900, and divided into two detachments, one under Lieutenant Ferguson and accompanied by Lieutenant Wooten, and the other under Lieutenant Oakes, accompanied by Lieutenants Cheney and Stickle.

They first advanced into Cavite Province by way of Laguna de Bay as a part of General Schwan's command. The second advanced into Cavite Province from Manila via Paranaque, Baccor, Imus, Dasmarinas, to Silang, where the columns joined on January 10. The work of these detachments consisted in the emergency repair of roads and bridges, the second detachment continuing its work from Silang to Naic via Indan.

Numerous route sketches and reconnoissances were made by these detachments. The second detachment returned to Manila the latter part of January, and the first detachment on February 7.

Lieutenant Stickle was assigned to command the detachment at Bayambang, which had been placed under the immediate command of the Commanding General of the 2d Division, General MacArthur.

Temporary repairs to roads and bridges were made by this detachment as follows:

January 27–28. Panique to Cuyapo via Anas, 10 miles.

January 29–31. Panique to San Juan de Guimba via Pura, 13 miles.

On this road a trestle bridge 50 feet long was built with lumber from churches in Pura.

February 3–9. Bautista to San Jose via Rosales, Humingan, and Lupao, 42 miles.

February 10–13. Humingan to San Nicolas via San Quintin and Tayug, 15 miles. This included much corduroying of extremely bad roads.

February 14–15. Tayug to Rosales via Santa Maria, 14 miles.

February 17–March 6. Lieutenant Stickle with part of the detachment inspected roads and submitted reports and estimates for temporary repairs to roads and bridges on Dagupan-Tayug line of communication, with all cross roads, traveling 140 miles.

March 7–18. This detachment inspected roads and submitted reports with estimates for temporary repairs to roads and bridges from San Fernando to Bongabong, and return to railroad at Malolos, traveling about 140 miles.

On March 29 the detachment was assigned to the 3d District, under the immediate orders of General J. Franklin Bell, and had charge from that time of the road and bridge repair of the Dagupan-Tayug line of communication for which estimates had been previously submitted, and for which funds had been allotted. The detachment was engaged on this work till October 18. About $25,000 worth (Mexican currency) of lumber was purchased and used in the construction and repair of bridges and about the same amount of money was used in the hire of natives for labor on roads and bridges and for carts for hauling. The length of the road worked upon was about 50 miles. Six pile bridges were built of varying lengths up to 638 feet. The road work consisted in ditching and grading. The general width between ditches was 20 feet. Two churches, one of which had been ruined by earthquakes, were blown down and the bricks of which they were built were broken and placed on the road. This was done where no gravel was available. At other places a great deal of gravel was hauled by carts and placed on the road. As the rainy season began about June 15, it found the work going on and the roads not in the best condition for it in many places, the time being short, the mileage of the road under repair so great, and the detachment so small. The detachment was divided into two parts for the work, a bridge detail and one supervising native work on roads, the latter subdivided into small details, never more than three men working at one place. Bridge work continued throughout the rainy season, but road work except emergency repairs had to cease.

From January 1 to May 1, 1900, small details of the company were continually called for, for engineer work outside of Manila, among them being a detail for railroad work February 22 to April 21; one at Tarlac, March 4 to March 6; one at Bamban, March 4 to March 13, and a detail for surveying at Vigan, January 23 to May 1.

A detachment of 24 enlisted men of the company, commanded by Lieutenant Ferguson, was in the South Camarines from February 15 to May 20, 1900.

Lieutenant Stickle commanded the company from May 1 to October 1. It was assigned to the Department of Northern Luzon with station at Bayambang, and moved to that station April 28. Details from the company were from that time on constantly required for reconnoissance, road and bridge work, as well as for the construction of scaffolds for execution of sentenced natives throughout the department.

On August 1, while on reconnoissance duty near San Isidro under 1st Lieutenant F. W. Altstaetter, Corps of Engineers, three enlisted men were captured after a prolonged resistance on the part of Lieutenant Altstaetter's command of about 14 men, Lieutenant Altstaetter himself being captured. The insurgents numbered several hundred. The enlisted men of the company captured were:

1st Class Private Edward Long.
1st Class Private Henry J. Walsh.
1st Class Private Henry T. Crenshaw.

Private Long was severely wounded in the abdomen and was released by the insurgents on August 1, and the other two men were released August 26 and joined the company.

The company was stationed at Bayambang till October 11, when it changed station to Dagupan. 2d Lieutenant L. H. Rand, Corps of Engineers, joined the company September 4, and 1st Lieutenant J. B. Cavanaugh joined company October 1 and assumed command.

Lieutenant Cavanaugh continued the improvements of the Dagupan-Tayug line and other roads with part of the company till July 11, 1901.

Lieutenant Stickle, with a detail of 25 men, took station at Humingan, Province of Nueva Ecija, December 15, 1900, charged with the repair of roads and repair and construction of bridges from Bautista to San Quintin and from Humingan to San Jose. The work of the repair of roads and repair and construction of bridges from San Jose to Cabanatuan was also given to this detail later, making the total number of miles of road to be repaired by this detail, 84. Not all of this was worked, however. On May 18, 1901, Lieutenant Stickle was relieved by 2d Lieutenant C. O. Sherrill, Corps of Engineers, who remained in charge of the work until July 16.

Lieutenant Rand, with a detachment of 24 enlisted men, took station at Alaminos, Province of Zambales, charged with the repair of roads and the repair and construction of bridges in the Province of Zambeles, on which the detachment was engaged until July 16, 1901.

On July 17 the company, consisting of 57 enlisted men commanded by Captain J. B. Cavanaugh, left Dagupan and proceeded to Manila, where Captain Cavanaugh was relieved from command by Captain W. E. Craighill, and 1st Lieutenant F. W. Altstaetter joined the company.

On July 19, 1901, the company, consisting of Lieutenant Altstaetter and 57 men, commanded by Captain Craighill, embarked on the United States transport *Sheridan* and sailed for San Francisco, Cal., July 20, arrived at Nagasaki, Japan, July 25; sailed for Yokohama, Japan, July 30; left Yokohama August 3, and disembarked at San Francisco, August 18. The company went into camp where it remained until August 23, when it proceeded by rail to Fort Totten, New York, arriving at that place August 21.

Engagements against insurgents in which the company or parts thereof took part, with date, place, and names of killed or wounded.

Engagement.	Date.	Killed or wounded.
Battle of Manila	Aug. 13, 1898	
San Pedro Macati	Feb. 5, 1899	
Pateros	Feb. 15, 1899	
In advance to Malolos	Mar. and Apr., 1899	2d Cl. Pvt. Thomas Sweeney, wounded in neck, slight.
Attacks on San Fernando	May, June, July, 1899	
Las Pinas Ford	June 10, 1899	
Calulut	Aug. 9, 1899	
Cavite Viejo	Oct. 8, 1899	
Putol	Oct. 9, 1899	
Rosario	Oct. 9, 1899	
Near Santa Cruz de Malabon	Oct. 10, 1899	2d. Cl. Private John I. Van Ness, wounded, serious.
Near San Francisco de Malabon	Oct. 10, 1899	
Angeles	Oct. 16, 1899	
Magalang	Nov. 5, 1899	
Bamban	Nov. 11, 1899	
San Fabian	Nov. 14, 1899	
Near Santo Tomas	Nov. —, 1899	
Mangatarem	Nov. 25, 1899	
Near San Isidro	Aug. 1, 1900	1st Cl. Pvt. Edward Long, wounded, serious.
Batoc, Province Ilocos Norte	Dec. 30, 1900	2d Cl. Pvt. George H. Rae, killed.

During its tour in the Philippines the company was stationed at the following places:

Cavite Arsenal, August 1, 1898, to August 7, 1898.
Camp Dewey, August 8, 1898, to August 13, 1898.
Binondo, Manila, August 14, 1898, to December 29, 1898.
Convent de Malate, Manila, December 30, 1898, to April 28, 1900.
Bayambang, April 29, 1900, to October 11, 1900.
Dagupan, October 12, 1900, to July 17, 1901.

Portions of the company were stationed at or near the following places at the following dates:

San Fernando, May 5, 1899, to August 8, 1899.
Quingua, June 20, 1899, to July 15, 1899.
Balic Balic, July 5, 1899, to October 26, 1899.
Paranaque, August 3, 1899, to August 15, 1899.
Imus, August 7, 1899, to August 14, 1899.
Calulut and Angeles, August 9, 1899, to November —, 1899.
Laguna de Bay, August 16, 1899, to October 2, 1899.
Zapote, August 20, 1899, to August 31, 1899.
Quingua, August 23, 1899, to August 31, 1899.
Pasig, August 29, 1899, to September 30, 1899.
Caloocan, August 29, 1899, to September 26, 1899.
Santa Mesa, September 2, 1899, to September 26, 1899.
Engineer depot, Manila, September 8, 1899, to October 19, 1899.
San Fabian and vicinity, November 5, 1899, to December 20, 1899.
Tarlac, November 14, 1899, to December 17, 1899.
Calasiao, November 24, 1899, to December —, 1899.
Bayambang, December —, 1899, to March 30, 1900.
Vigan, January 23, 1900, to March —, 1900.
Bamban, March 4, 1900, to March 13, 1900.
Dagupan, March 30, 1900, to October 11, 1900.
Rosales, May 15, 1900, to May 27, 1900.
Mangaldan, April 1, 1900, to October 1, 1900.
San Fabian, same.
San Jacinto, same.
Manaoag, same.
Binalonan, same.
San Manuel, same.
Asingan, same.
Calasiao, same.
Urdaneta, same.

Pozonubio, December 2, 1900, to December 10, 1900.
Humingan, December 15, 1900, to July 16, 1901.
Alaminos, December 15, 1900, to July 16, 1901.
Mangaldan, January 29 to March 4, 1901.
Camiling, March 1, 1901, to July 16, 1901.
Tayug, March 11, 1901, to July 16, 1901.
San Felipe, March 17, 1901, to ———.
Salasa, March 27, 1901, to ———.
Binmaley, April 3, 1901, to ———.
Bautista, February 1, 1901, to July 16, 1901.
Alcala, February 1, 1901, to July 16, 1901.
Rosales, February 1, 1901, to July 16, 1901.
San Jose, January 1, 1901, to June 15, 1901.
Taleveia, February 1, 1901, to July 16, 1901.
Cabanatuan, February 1, 1901, to July 16, 1901.

Officers serving with Company A, 1st Battalion of Engineers, from May 24, 1898, when the company left Willets Point, N. Y., for the Philippine Islands, until August 29, 1901, when it arrived at Fort Totten, Willets Point, N. Y., on its return from the same, giving dates of joining and relief:

Name and rank.	Joined.	Relieved.
Additional 2d Lieut. W. D. Connor	May 25, 1898	Aug. 30, 1898.
1st Lieut. C. P. Echols	May 25, 1898	Nov. 11, 1898.
Capt. W. C. Langfitt (appointed Major, U. S. Volunteer Engineers).	June 2, 1898	June 20, 1898.
Additional 2d Lieut. Kerr	June 19, 1898	Died July 21, 1898.
2d Lieut. P. H. Mullay	Aug. 2, 1898	Aug. 8, 1898.
1st Lieut. M. G. Krayenbuhl, Artillery	Sept. 5, 1898	Sept. 7, 1898.
1st Lieut. W. G. Haan, Artillery (appointed A. Q. M., U. S. V.)	Sept. 8, 1898	Mar. 5, 1899.
1st Lieut. W. P. Wooten	Feb. 28, 1899	Sept. 30, 1900.
Capt. F. R. Shunk	Mar. 13, 1899	Feb. 19, 1900.
2d Lieut. H. W. Stickle	Apr. 24, 1899	May 18, 1901.
1st Lieut. S. A. Cheney	Nov. 3, 1899	Dec. 23, 1899.
1st Lieut. J. B. Cavanaugh	Oct. 1, 1900	July 18, 1901.
2d Lieut. L. H. Rand	Sept. 5, 1900	July 16, 1901.
1st Lieut. F. W. Altstaetter	July 18, 1901	Aug. 29, 1901.
2d Lieut. C. O. Sherrill	May 1, 1901	July 16, 1901.
Capt. W. E. Craighill	July 18, 1901	Aug. 29, 1901.

COMPANY B.

In accordance with G. O. No. 9, Headquarters of the Army, A. G. O., Washington, D. C., June 15, 1899, Company B, Battalion of Engineers, commanded by Captain William L. Sibert, with 1st Lieutenant John C. Oakes and 2d Lieutenant Harley B. Ferguson, of the Corps of Engineers, and 150 enlisted men left Willets Point, N. Y., at 7 a. m. July 5, 1899, for the Philippine Islands via San Francisco, Cal. Left San Francisco, Cal., July 13, 1899, on the United States Army transport *City of Para*, stopped three days at Honolulu, H. I., en route, and arrived in Manila Bay August 10, 1899, landed August 13, and proceeded to Malate Barracks, Malate, P. I.

The company remained in Malate until the morning of August 17, when it proceeded to San Fernando, Province of Pampamga by rail, arriving at 2:40 P. M. same day. This P. M. Captain Sibert with Lieutenant Ferguson and 40 men left for Angeles Bridge, a distance of 11 miles, and arrived at 5 A. M. the 18th. The detachment was considerably delayed in reaching Angeles, due to darkness and bad roads which were all flooded at that time. Here the detachment rescued two railroad engines which were run through a broken span in the bridge by the insurgents. While this work was being done the men were continually under fire from the insurgents, and at times work had to cease, the detachment taking its plaee upon the firing line with the 12th Infantry until the firing ceased sufficiently for the detachment to return to its task. The detachment returned to San Fernando, August 20, 1899.

August 23, Lieutenant John C. Oakes with 50 men left for Apalit, a station on the railroad, to relieve one company of the 16th Infantry.

The detachment took charge of the station and guarded the track from Calumpit to Kilometre 55. The detachment returned to San Fernando September 16, 1899.

The company furnished guards for General MacArthur's headquarters, outposts along the railroad, train guards, escorts for ration and ammunition trains, and made reconnoissance maps of the country surrounding San Fernando for a radius of seven miles, which were compiled and sent to the Chief Engineer of the Department of the Pacific and 8th Army Corps, Manila. These duties were carried on from August 17 to October 2, 1899.

September 27, Lieutenant Ferguson with 60 men left for the advance on Porac. This detachment was divided into two details which assisted the artillery in advancing the field pieces. Porac was taken September 28, and from there the detachment proceeded to Angeles, arriving September 30, 1895. Forty men of the detachment remained at Angeles and were assigned to the 2d Division, 8th Army Corps. The remainder of the detachment returned to San Fernando October 1.

October 2, 40 men were left at San Fernando for assignment to the 1st Division, 8th Army Corps, and the remainder of the company, commanded by Lieutenant J. C. Oakes, proceeded to Manila. One noncommissioned officer and four privates were left at San Fernando in charge of the armored car.

On October 3 the Manila detachment left Malate Barracks at 11 A. M. with a detachment from Company A, engineers, and proceeded to Pasay to relieve two companies of the 13th Infantry, which were sent out on a reconnoissance. Here outpost duty was performed and the detachment returned to barracks October 4, 1899.

October 5 the detachment again left for Pasay and from there went to Paranaque for guard duty, remained there until 11 A. M. the 6th, when the detachment left for the Big Bend, just beyond Bacoor, and there a rope ferry was put in. This ferry was constructed of such materials as could be found. Filipino dugouts (bancos) were used and the balk and flooring of the ferry was taken from buildings in the vicinity.

The ferry was completed at 12:30 A. M. the 7th, and at 3 A. M. General Schwan's advance guard crossed the river (Imus River) for advance on Cavite Viejo. The entire column consisting of about 1,200 men and two field pieces crossed before 6:30 A. M., and the advance on Cavite Viejo commenced.

A detachment of 40 men, commanded by Captain Sibert, left with the advance guard and the field pieces. This detachment was continually under fire until 11 A. M., when the town was taken.

From this place hardly any resistance was met with during the expedition and the column passed through Noveleta, Rosario, Santa Cruz, San Francisco de Malabon, Dasmarinas, and returned to Manila via Imus, arriving October 14, 1899.

At San Francisco de Malabon one non-commissioned officer and twelve privates were assigned to duty with Captain Riley's battery as artillerymen and were highly commended by Captain Riley for their valuable assistance.

No further duties were performed by this detachment until October 24, when it was divided and sent to join the detachments on the north line.

The detachment left at San Fernando and assigned to the 1st Division, 8th Army Corps, commanded by General Lawton, started in the general advance north October 10, through Mexico, Santa Ana, Arayat, Cabiao, San Isidro, Santa Rosa, Cabanatuan, Talaveria, San Jose, Lupao, Humingan, San Quintin, Tayug, San Nicholas, San Manuel, San Miguel, and Binolonan.

The work of this detachment consisted in repairing all roads traveled, putting in ferries and bridges and making maps of the entire route. As far as San Isidro the detachment kept well up with the column, but from there on the detachment proceeded to Binolonan independently.

Four large bridges and four ferries were built and many small bridges and culverts repaired. Many of the roads had to be corduroyed, and in several places new roads had to be built through fields.

This detachment was greatly hampered on account of insufficient clothing and shoes, also rations, due to the difficulty in getting supplies from Manila. Many of the men became sick, and as very little medical attendance could be had, this again interfered with the progress of the detachment. At Talaveria the detachment was divided on account of the rapid rising of the river, 47 men, with Lieutenant Oakes, managed to cross, but 17 were left behind with the rations and told to cross when the river had fallen. The 47 men proceeded to San Jose, a distance of 16 miles, and did not arrive until the following day at 4 P. M., the delay due to roads flooded for miles and conditions already mentioned. Here the detachment remained three days waiting for the 17 men to catch up, when it continued on its journey to Binolonan, where headquarters of the company was established, and details were sent from here to Maniaug, San Jacinto, and San Fabian to repair roads and bridges.

While at San Isidro a large number of trestles were constructed for the purpose of putting a bridge across the river at this place but the work was abandoned and a ferrry was put in instead.

The trestles were used later at the Tombo and Taboatin Rivers.

While at Cabanatuan from October 1st to 14th, the bridges at the Tombo and Taboatin Rivers were carried away three times due to the sudden rising of the rivers from rains. At Cabanatuan two large ferries were put in (bamboo), but were carried away. The river here was very wide and the current very strong and swift. Later another ferry was put in about 200 yards below the first crossing after sufficient material had been received from Manila.

The lack of material and the sudden rising of the rivers from 18 to 25 feet made it impossible to put in any permanent work.

On October 27 this detachment was reinforced by 34 men from the Manila detachment which joined at San Isidro.

On November 10, 1899, one private left with General Young's Flying Brigade from Cabanatuan and made maps of all the roads traveled until Vigan was reached.

On December 1, the detachment returned from Binolonan to San Isidro where a bridge on the San Miguel road had to be repaired for the advance on San Miguel, December 9, 1899. Here the detachment bivouacked and took its place in rear of the advance guard the following morning. This city was taken without any resistance as the insurgents had left for the mountains.

Along this road eleven large bridges were repaired and the detachment arrived in San Miguel at 8 P. M. same day.

Here the column rested one day and then proceeded to Baliaug where a stop of three days was made. From here General Lawton was to take his column into the Mariquina Valley. This plan was abandoned and the 1st Division, 8th Army Corps, returned to Manila, arriving December 17, 1899.

The detachment left at Angeles repaired the railroad track and the Angeles bridge. They were constantly under fire until the work was completed. This lasted until November 2, 1899. Miles of railroad track had to be laid as the insurgents had taken the rails away and burnt the ties.

This detachment was reinforced by 26 men of the Manila detachment October 25, and joined at Angeles.

When General Lawton had gone well to the north, the advance along the railroad commenced November 6, 1899. Bambam was the first place to be attacked, where a stubborn resistance was made by the insurgents, which was broken by General Bell in reaching the insurgents right flank with the 36th Infantry, U. S. Volunteers.

Here the Bambam bridge was partly destroyed. The south abutment was entirely gone and one of the steel spans was dropped to the river bottom. This span was raised and placed back into place in the bridge. This span was 30 metres in length and weighed about 36 tons. A new abutment was put in and a three-bent trestle, 125 feet long, was built. Three of the steel pillars supporting the steel span were entirely destroyed and four large cribs were put in place to support this span. One-half of the detachment continued the advance to Tarlac where no resistance was met with. The advance continued until about four miles north of Tarlac when the washout was reached. Here the detachment rebuilt the railroad across the washout, a distance of two miles. All of this work was done by cribbing, the track being raised six feet. The bottom here was quicksand, which made the task a very difficult one.

From Tarlac the insurgents were pushed so rapidly that they did little or no further damage to the railroad.

From Tarlac to Dagupan little work was done outside of fixing the roadbed and replacing old ties.

On November 9, a detail of 20 men from the detachment left San Pedro de Magalang with the artillery and 17th Infantry, commanded by General Smith, and advanced on Conception, taking this town with hardly any resistance and from here proceeded to Capaz on the railroad.

This move was made to get in rear of the insurgents at Bambam, but due to impassable roads connections were not made.

After November 6, most of the detachment's time was consumed at the Bambam bridge and at the washout.

The detachment returned to Manila December 18, 1899.

From December 18 to 22, the company remained at the Cuartel de Malate, Malate, P. I.

On December 22, Lieutenant Oakes with 71 men proceeded by rail to San Fernando, Province of Pampanga, and from there marched through Mexico, Santa Ana, Arayat, Cabiao, San Isidro, Santa Rosa, to Cabanatuan to repair and replace bridges and ferries destroyed by the sudden rising of the rivers December 19, and returned to Manila December 31, 1899.

On January 2, 1900, Lieutenant Ferguson with 62 men joined General Schwan's column at San Pedro Macati, and January 5, Lieutenant Oakes with 75 men joined General Wheaton's column at Imus. January 6, the general advance south commenced.

This expedition was commanded by General Bates. The expedition passed through the Provinces of Cavite, Batangas, and Laguna. Lieutenant Ferguson with his detachment returned to Manila from Santa Cruz, February 5, 1900, and Lieutenant Oakes with his detachment returned February 11, 1900.

The duties performed were confined principally to road building and repairing, construction of and repair of bridges and ferries. Reconnoissance maps were made of all the roads traveled in this expedition.

On February 14, Lieutenant Ferguson with 24 men of the company left with the expedition for the Camarines and returned May 18, 1900.

The work of this detachment was in building and repairing bridges. In one stretch of 15 miles from Pasacao to Nueva Cacares 31 bridges were built and repaired. This detachment also acted as advance guard in several reconnoissances made to Legaspi, Daraga, and Pili and to other small towns in the interior.

From February 21 to May 31, 1900, a detachment consisting of two non-commissioned officers and 20 privates of the company had charge of the railroad and acted as engineers, conductors, station agents, and foremen in the car shops at Caloocan.

On April 1, the Department of the Pacific and 8th Army Corps was changed to the Division of the Philippines and divided into departments. Company B was assigned to the Department of Southern Luzon, and Lieutenant John C. Oakes was appointed Chief Engineer Officer of this

Department and work commenced in the repair of roads, bridges, and ferries.

Headquarters of the company was established at the Convent de Malate, where a regular supply depot was equipped (quartermaster and engineer) to furnish transportation and supplies to the detachments left in charge of work which was carried on at Paranaque, Bacoor, Imus, Dasmarinas, Silang, Indan, Naic, Batangas, San Jose, Lipa, Cabuayo, Calamba, San Pedro Macati, Mariquina, San Mateo, Pasig, Taguig, Santa Ana, and Pasay, all in the Department of Southern Luzon.

On October 6, 1900, two non-commissioned officers and two privates participated in the expedition to the island of Marinduque made by Genetal Hare, and returned October 30, 1900. The detachment made road maps of the island.

On March 1, 1901, a detachment of 20 men commanded by Lieutenant Kelly, left for the Camarines and repaired the roads and bridges from Legaspi to Nueva Cacares and to Pasacao.

Most of the roads at the above places were entirely rebuilt and many kingpost and queenpost bridges were put in. Ferries were also put in at Pasig and at the Big Bend on the Imus River.

This work continued until September 23, 1901, when the company was assembled in Manila to return to the United States.

Second Lieutenant Walter H. Lee, Corps of Engineers, on duty at Lipa, in connection with the repair of roads and bridges, accompanied two companies of the 21st Infantry June 10, 1901, on a reconnoissance to the mountains and was killed just outside of Lipa, Province of Batangas, Luzon, P. I. Lieutenant Lee was shot in the left wrist and again through the intestines.

On June 27, 1900, Lieutenant Ferguson with a detachment of 20 men left with the First China Relief Expedition and arrived at Taku July 6, 1900. The detachment were present when assault was made on the walled city at Tientsin July 13, 1900; with advance to relief of Pekin, August 4, and present at battle of Pietsang, August 5, Yangtsun, August 6, Chumen and other gates to sacred city of Pekin, August 15, 1900. Maps were made of the roads traveled from Tongku to Pekin and maps of the cities of Pekin and Tientsin were made by the detachment. This detachment returned to Manila June 5, 1901.

The company left the Philippine Islands October 18, 1901, for the United States via the Suez Canal, and stopped at Singapore, Colombo, Suez City, Port Said, Malta, Gibraltar, and Bermuda, and arrived in the United States December 23, 1901.

Following are the names of officers who served with Company B, 1st Battalion of Engineers, during the periods mentioned herein:

	Joined.	Relieved.
Captain William L. Sibert	Sept. 25, 1898	Sept. 17, 1899.
1st Lientenant John C. Oakes	Oct. 19, 1898	May 23, 1901.
1st Lieutenant Sherwood A. Cheney	Sept. 3, 1900	Apr. 19, 1902.
1st Lieutenant Harley B. Ferguson	Dec. 11, 1898	Sept. 12, 1901.
2d Lieutenant William Kelly	Sept. 3, 1900	Sept. 20, 1901.
2d Lieutenant Walter H. Lee	Apr. 26, 1901	Killed June 10, 1901.
2d Lieutenant William G. Caples	Apr. 26, 1901	Sept. 20, 1901.

STATIONS.

Manila, December 17, 1899, to October 18, 1901.

San Fernando, August 16, 1899, to October 2, 1899.

Manila, October 3, 1899, to October 16, 1899.

LAWTON'S ADVANCE.

North, October 17, 1899, to December 16, 1899.

Camarines, February 15, to May 18, 1900; February 28, 1901, to September 6, 1901.

Calamba, October 27, 1900, to September 23, 1901.

Indan, Naic, Silang, Imus, October 27, 1900, to June 30, 1901.

Yangstung, Pietsang, Tientsin, Pekin, China, July 13, 1900, to May 30, 1901.

The above is taken from the company monthly reports of operations and the morning report.

COMPANY C.

Company E, Battalion of Engineers, left West Point, N. Y., July 24, 1900, under command of Lieutenant J. B. Cavanaugh, Corps of Engineers, pursuant to paragraph 2, G. O. 90, A. G. O., 1900.

The strength at time of leaving was 150, rank and file, recently increased from 100 by transfers from other companies. Five were left at the post, reducing the company to 145.

Without incident the company reached San Francisco, Cal., July 29, 1900, remained three days at the Presidio, during which it was paid for two months (one in advance), and sailed on the United States Army transport *Meade* on August 1, 1900.

The transport touched at Japan and reached Manila September 3, 1900. On eptember 6, the company debarked at Manila, moved by rail to Caloocan and went into quarters. Caloocan remained the headquarters of the company during the year.

roads in the vicinity of Caloocan, from October 25 to November 17.

Lieutenant Burgess examined and reported upon the condition of the bridge at Orani.

NOVEMBER, 1900.

One sergeant and six privates at Pasig repairing steel cable used by ferry, from November 10 to December 2.

DECEMBER, 1900.

Additional 2d Lieutenant Slattery, one sergeant, two corporals, and sixteen privates on detached service at Vigan in charge of and overseeing the construction of military road, from December 9, 1900, to September 15, 1901. (Lieutenant Slattery returned to company February 25, 1901.)

One corporal and five privates on detached service at Dagupan guarding public funds, from December 18 to December 25.

One corporal and four privates on detached service at Dagupan guarding public funds, from December 25 to December 30.

The company received 12 horses and 28 mules during the month.

JANUARY, 1901.

One sergeant and six privates on detached service at Arayat overseeing construction of roads and bridges, from January 17 to July 17.

1st Lieutenant Alstaetter, one sergeant, two corporals, and twelve privates on detached service at Arayat overseeing construction of roads and bridges, from January 29 to August 5. (Lieutenant Altstaetter was assigned to and joined company January 21.)

One sergeant, one corporal, and seven privates on detached service at San Isidro overseeing construction of roads and bridges, from January 29 to August 5.

During the month the company received 6 horses and 36 mules for road work.

FEBRUARY, 1901.

Three privates on detached service at Quingua overseeing construction of roads, from February 3 to August 1.

One sergeant and six privates on detached service at San Mateo overseeing the construction of roads and bridges, from February 8 to September 15.

One corporal and three privates on detached service at San Isidro overseeing construction of roads and bridges, from February 12 to September 1.

Four privates at Arayat overseeing construction of roads and bridges, from February 12 to September 2.

One sergeant and four privates on detached service at San Isidro overseeing construction of roads and bridges, from February 21 to September 1.

One corporal and four privates on detached service at San Felipe overseeing construction of roads, from February 21 to March 26.

Lieutenant Slattery on detached service at Arayat from 5th to 18th in charge of construction of roads and bridges.

MARCH, 1901.

Lieutenant Slattery on detached service at Arayat in charge of construction of roads and bridges from March 7 to July 2.

One sergeant, one corporal, and eight privates on detached service at Baliuag overseeing construction of roads and bridges, from March 7 to August 1.

Two privates on special duty overseeing repairs to road in vicinity of Caloocan, from March 12 to April 15.

Two privates on detached service at Quingua overseeing construction of roads from March 18 to July 7.

Five horses and 30 mules received during the month for road work.

APRIL, 1901.

One corporal and five privates at Angeles overseeing construction of roads, from April 10 to September 14.

Two privates on detached service at Quingua overseeing road work, from April 18 to July 7.

2d Lieutenant Slattery on detached service at Quingua in charge of construction of roads and bridges, from April 19 to August 1.

MAY, 1901.

One corporal on detached service at Quingua overseeing construction of roads, from May 16 to July 7.

Lieutenant Burgess was relieved from command of company, and Lieutenant Altstaetter assumed command.

1st sergeant was promoted to battalion sergeant major, and company quartermaster sergeant promoted to battalion quartermaster sergeant.

Thirty-two mules were received during the month for road work.

JUNE, 1901.

Designation of company changed from E, Battalion of Engineers, to Company C, 1st Battalion of Engineers, and strength increased to 164, rank and file, per G. O. 22, A. G. O., February 26, 1901.

Eleven men transferred to Company D, 1st Battalion of Engineers, about to be organized.

JULY, 1901.

Lieutenant Altstaetter was relieved from duty with the company, three men were transferred to the company, and thirty-one transferred to Company D, 1st Battalion of Engineers.

During the month 224 mules and 26 horses were employed on road work by the company.

The 2d Battalion of Engineers having arrived from the United States, the details from the 1st Battalion were ordered in, preparatory to the battalion returning to the United States.

AUGUST, 1901.

The company was formed at Cuartel de Malate by the returning detachments preparatory to embarking on the U. S. Army transport *McClellan* for return to the United States.

SEPTEMBER, 1901.

Lieutenants Spalding and Slattery, Corps of Engineers, were relieved from duty with the company, and 1st Lieutenant Harry Burgess, Adjutant, 1st Battalion of Engineers, assigned to command.

The company embarked on the U. S. Army transport *McClellan*, October 17, 1901, and reached New York, December 23, 1901, touching at Singapore, Colombo, Suez, Port Said, Malta, Gibraltar, and Bermuda en route. On December 24 the company returned by train to West Point. The health of the company was excellent throughout the voyage.

The following is a list of the officers serving with the company during its tour abroad:

Captain George A. Zinn, Corps of Engineers, July 30, 1900, to September 7, 1900.

1st Lieutenant J. B. Cavanaugh, Corps of Engineers, July 18, 1900, to September 17, 1900.

1st Lieutenant Harry Burgess, Corps of Engineers, July 30, 1900, to May 31, 1901; from September 23, 1901, to December 24, 1901.

2d Lieutenant John R. Slattery, Corps of Engineers, July 17, 1900, to September 23, 1901.

2d Lieutenant George R. Spalding, Corps of Engineers, April 30, 1901, to September 23, 1901.

2d Lieutenant Frederick W. Altstaetter, Corps of Engineers, January 22 to July 17, 1901.

Stations of the company while in the Philippine Islands.

Month.	Headquarters.	Detachments other than at headquarters.
September, 1900	Manila-Caloocan	5, Manila; 7, Pasig.
October, 1900	Caloocan	2, Mariquina; 2, Marinduque; 5, Northern Luzon; 5, San Felipe; 7, near Caloocan.
November, 1900	do	7, Pasig.
December, 1900	do	20, Vigan; 6, Dagupan.
January, 1901	do	16, Arayat; 9, San Isidro.
February, 1901	do	3, Quingua; 7, San Mateo; 5, San Isidro; 5, Arayat; 5, San Felipe.
March, 1901	do	10, Baliuag; 2, Quingua.
April, 1901	do	6, Angeles; 3, Quingua.
May, 1901	do	1, Quingua.
June, 1901	do	
July, 1901	do	
August, 1901	Cuartel de Malate	
September, 1901	do	
October, 1901	Cuartel and U. S. A. transport *McClellan*.	

COMPANY D.

Company D, 1st Battalion of Engineers, was organized in the Philippine Islands, June 7, 1901, and brought to its authorized strength entirely by transfers from Companies A, B, and E, of the original Battalion of Engineers made in compliance with G. O. No. 3, Headquarters 1st Battalion of Engineers, under the provisions of G. O. No. 22, Headquarters of the Army, A. G. O., February 26, 1901. The enlisted men transferred to the company were, at the time, employed on road and bridge work at various points throughout the island of Luzon, but their stations and duties were unchanged by their transfers.

From June 13 to July 11, 1901, Lieutenant H. Burgess, Corps of Engineers, was in temporary command of the company, with station at Manila, P. I. On July 11 he was relieved by Captain J. B. Cavanaugh, Corps of Engineers, and on July 30 the company was assigned to duty in the Department of Northern Luzon, with station at Dagupan, P. I. On September 27 the company was relieved from duty in this department and ordered to join the 1st Battalion of Engineers at Manila, P. I., to await transportation to the United States. Those members of the company in the Department of Southern Luzon were similarly relieved and joined their company in time to embark for the United States on the United States Army transport *McClellan*, sailing from Manila for New York October 18, 1901.

While the history of Company D, 1st Battalion of Engineers, as an organization begins June 7, 1901, the date of organization, that of its enlisted strength is embodied in the histories of the three older companies of the 1st Battalion from which these men were transferred, for prior to June 7 they were members of these three companies and took an active part in all engineering work in China and the Philippine Islands upon which these companies were engaged.

During the short period from the organization of the company until its departure from the Philippine Islands the duties of the companies were in connection with the repair and construction of roads and bridges and consisted merely in the discharge of duties already assigned to the officers and enlisted men as members of the other three companies. These duties are included in sketches of the operations of these companies.

The stations of the different detachments of the company were as follows:

In Northern Luzon—At Dagupan, Captain J. B. Cavanaugh, company headquarters and 19 enlisted men; at Vigan, 1 man; at Binalonan, 4 men; at San Jacinto, 2 men; at Salasa, 3 men; at Alaminos, 3 men; at Bani, 2 men; at Agno, 2 men; at Camiling, 4 men; at Manila, 8 men; at San Quintin de Albai, 2 men; at Pasig, 2 men; at Caloocan, 29 men; at Balinag, 2 men; at San Isidro, 2 men; at Angeles, 1 man, and at Orani, 2 men.

In the Department of Southern Luzon—At Pili, 5 men; at Pasacao, 2 men; at San Tomas, 4 men, and at Calamba, 4 men.

There was also one sergeant sick in hospital at Corregidor Island.

In addition to Captain Cavanaugh, the following officers served with the company: 1st Lieutenant L. H. Rand, who was assigned to the company July 11, 1901, with station at Alaminos, in charge of road work in the Provinces of Pangasinan and Zambales, and 2d Lieutenant C. O. Sherrill, who was assigned to the company July 27, 1901, with station at Arayat, in charge of road work in that vicinity.

Both Lieutenant Rand and Lieutenant Sherrill were relieved from duty with the company September 20, 1901.

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TRANSLATOR'S NOTE.

Major Bornecque's monograph deals, as he states, with the subject of Demolitions or the Destruction of Obstacles in Campaign only in their relation to the work of tactical troops, mainly the infantry and cavalry, and intentionally omits serious treatment of the more systematic and extensive operations of technical troops, the engineers, along the same lines. It contains, however, some considerations that are worthy the attention of all officers and warrant its printing in English, although in many respects his treatment of the subject is sketchy.

The material and methods described are those of the French land forces and among the former appears melinite as the high explosive adopted for all uses in the field for which black powder is not suitable. Melinite is supplied to the troops in cylindrical and rectangular cartridges inclosed in metal cases. The former are called *cartouches* or cartridges; and the latter are known as *petards*, and this word has been retained in the translation for want of a better one distinctive from cartridge. The petard form is distributed to all regiments of infantry and cavalry in quantities that will be found in the text.

Little information is given regarding melinite outside of the makeup of the cartridges and petards and the methods and quantities to be employed in various demolitions. It is, however, stated that dynamite (presumably dynamite No. 1), may be substituted for melinite and is equally powerful weight for weight although of less density and therefore of greater bulk than the latter. For reasons other than their relative strengths, melinite has replaced dynamite in the French army and, assuming them to be of equal strength as stated in the text, all of the statements as to weights of charges may be considered as applying to dynamite No. 1.

For the convenience of the reader, all formulas and quantities have been transposed from the metric to the English system of units. In all instances the transposition is no more exact than the circumstances appear to warrant.

WASHINGTON BARRACKS, D. C., *August, 1902.*

the theoretical and practical considerations relating to each, it nevertheless appears indispensable that all officers should know the extent of the coöperation to be expected from other arms or that can be given to engineer troops if any are available.

In other words, it is desired to place all detachment commanders, who may find their progress stopped by an unexpected obstacle, in a position to solve a problem such as the following: Given certain tools, explosives, and men and a certain amount of time for the destruction of an obstacle that prevents the advance of the army, what shall be done to obtain the best results?

No hesitation has been felt in going into the subject extensively and while not treating it completely, especially as to the special duties of the engineers, an attempt has been made to give a fair knowledge of all cases that may arise in the field and of the means to be used to overcome them.

THE DESTRUCTION OF OBSTACLES IN CAMPAIGN.

CHAPTER I.

GENERAL REMARKS.

NECESSITY AND OBJECT.

An army in the field often finds it necessary, when in the presence of the enemy, to carry out many demolitions in its own territory as well as that of the enemy.

Indeed, an army may find it necessary—

1. To delay the advance of the enemy by interrupting or partially destroying such lines of communication as he might use.

2. To remove obstacles that interfere with the movement or the fire of its own troops.

3. To avoid leaving in the hands of the enemy either materials or supplies that can not be carried away nor used under the conditions to be found after its withdrawal but that might be of use to the enemy.

LEGITIMACY.

In time of war it is hardly possible to limit the rights of the victor or to discuss the legitimacy of the measures taken by the vanquished for the defense of the country. It is generally admitted, however, that the only permissable demolitions are those required by *military necessities*.

But it is difficult to define accurately the scope of this phrase, of which the interested parties are themselves the judges. It seems, however, that *a priori*, all measures should be excluded that have for their object only the spreading of terror among the people and of making reprisals for defeats or checks that have been suffered.

THINGS SUBJECT TO DEMOLITION.

When acting in good faith, demolitions should be limited to those that harm the belligerents and have a direct relation to a definite operation of war, as was stated above.

From this point of view a study should be made of the methods to be employed for the destruction of highways, railways, all lines of communication, materials that would facilitate the enemy's movements and places, minor defenses, walls and other things that would interfere with the movement of our own troops.

SOURCE OF AUTHORITY.

As the extensive destruction of lines of communication has a considerable influence on the operations of armies from both the strategic and the tactical point of view, it is generally admitted that the only judge of the nature and extent of such demolitions, must be the military commander who alone can be held to account for the resulting consequences. So far as concerns railroads, the rule is absolute that bridges, viaducts and culverts are not to be destroyed or rendered unserviceable without the formal written order of the commander-in-chief of the army or of the generals to whom he has specifically delegated such authority.

The decision in such cases depends much on circumstances and prospective movements—whether it is intended to take the offensive or beat a retreat, etc. Above all, it is always necessary, to consider carefully the extent and importance of demolitions both as to their immediate results and as to their possible future effects upon the army causing them.

Indeed, the ill-timed or premature destruction of a highway, railroad, and especially of a bridge, may deprive an army of a valuable means of passage and have extremely serious consequences, resulting, under certain conditions, in cutting off the retreat of many troops (bridge of Lindenau, over the Elster, at the battle of Leipzig). During the war of 1870, there were destroyed precipitately and often without discrimination, many bridges, viaducts and tunnels which, if left intact, would have proved very useful in subsequent operations.

On the contrary, the commander-in-chief who fails to have made in time such demolitions as are necessary, furnishes the enemy with an easier way of reaching him and thus deprives himself sometimes of a chance for success (bridges over the Mozelle above Metz, bridge of Donchery over the Meuse, and the Saverne tunnel, in 1870.)

On railroads and highways the destruction of bridges, viaducts and culverts can alone have serious results, and it is necessary that measures preparatory to their demolition should be taken in time of peace if such demolition is to be effective at the opportune moment. As the repair of such structures is difficult and expensive, requiring much time, their destruction in a friendly country should be resorted to only in cases of absolute necessity.

FORMAL ORDERS.

Orders for the destruction of railroads should always state—

1. The exact location, character and extent of the demolition.
2. The minimum time for which the road is to be rendered impassable.

To meet the latter requirement, the officer charged with the duty should seek out such structures upon the line to be cut as will, by their destruction, prevent the re-opening of traffic over the road within the specified time. It is equally essential that these orders shall state the time allowed for making such demolitions, in order that they shall certainly be effected within the desired time.

VALUE OF DEMOLITIONS.

The value of demolitions does not depend solely upon the character of the works destroyed and varies with the local conditions.

Thus, the destruction of a tunnel or an important bridge is of more or less value depending upon the necessity of repairing it in order to re-establish communication and the possibility of passing around it by means of a detour.

The suspension of traffic by the destruction of roadbeds, turnouts, crossings and bridges with a span less than 10 or 12 meters [33 to 39], is usually of short duration.

On the other hand, the destruction of pumps, water pipes, bridges and viaducts of spans greater than 12 meters, high embankments and deep cuts in bad ground, may make necessary extensive repairs, covering time enough to serve one's purpose, and the destruction of unusually long bridges and tunnels may close a road for a very long time.

EXECUTION.

Demolitions may have to be carried on in the presence and under the fire of the enemy or at a distance from him, depending upon circumstances.

In the latter case, the cavalry may be charged with the most urgent demolitions and those that will not permit of delay, particularly during the period of mobilization and upon lines useful to the enemy for concentrating his troops. This may also be the case in the attack of a fortified place in order to cut its lines of communication preliminary to its investment.

Infantry will, in general, be required to carry out only such hasty demolitions as the opening of breaches, the removal of obstacles, the disabling of war material, artillery and railroads and the destruction of telegraph lines and bridges of minor importance.

It is possible also by rapid movements to make demolitions which, while of minor importance, will nevertheless greatly disorganize the transport service and line of communication in rear of an army. Bicyclists may be advantageously used for work of this character.

Demolitions may therefore be made by troops of all arms, within the limits of the means at their disposal, but those just mentioned, particularly such as are hastily executed, can not be very extensive or of lasting importance in view of the fact that but a small amount of explosive (melinite) is carried by the troops referred to.

But when demolitions of importance are undertaken at a considerable distance from the enemy and in all cases where serious breaks, requiring much work and large quantities of explosives, are to be made in lines of communication, whether at a distance or in the presence and under the fire of the enemy, the work devolves upon Engineer troops. Indeed, these troops alone are equipped with the necessary tools and explosives, and have the training and ability requisite to secure success with certainty under the given conditions and within the desired time.

It is generally preferable to employ technical troops for demolitions whenever such troops are available as the use of explosives, in particular, requires much experience. If they are entrusted to inexperienced men, there is great danger of accidents and of failure, the consequences of which should be avoided as much as possible.

The destruction of tracks and bridges has been re-transferred to the officers of the railroad service, to be accomplished either by the troops of that service or by any others available for the purpose (Art. 54 of the Decree of November 19, 1889.)

An order for the demolition of works should in every case be carried out at all hazards, even though it should require a working party that seems entirely out of proportion to the immediate results obtained. Failure to execute rapidly and energetically the order given after the battle of Froeschwiller for blowing up the Arschwiller tunnel, resulted in the railroad line between Strasbourg and Paris not being broken at that point, although a break would have materially increased the difficulty of provisioning the German army from its base. Indeed, the steps taken for the execution of this order were not carried out rapidly enough to prevent the occupation of the tunnel by the Germans before the arrival of the French.

STRUCTURES TO BE DESTROYED.

In a general way, as has been stated above, structures of importance (bridges, tunnels, etc.), are destroyed if serious damage and the longest possible interruption of traffic is desired.

In obstructing highways, cuts should be made at the highest points of embankments and at low places where the cuts can perhaps be flooded, in order to make repairs slower and more difficult.

It is always preferable, in damaging railroads, to select such points as curves, junctions, high embankments, deep cuts, viaducts, tunnels, important stations and, in general, localities where the greatest injury can be done.

Strategical and tactical conditions may, however, be such as to require that lines of communication shall be destroyed only partially and in such a manner as to permit of their restoration in a very short time. In such cases the general rules laid down above should be followed and the extent of the damage should be varied to suit the strategical and tactical conditions that lead to it.

PRELIMINARY STEPS.

Telegraphic communications should be cut before commencing work to prevent the enemy gaining any knowledge of the undertaking.

In operating on railroads, irrespective of the damage to be done, all traffic should be interrupted at a distance of 500 or 600 meters on each side of the selected point by removing a few rails or by stationing men to signal all trains. In all cases the necessary military precautions must be taken to secure the working party from attack.

It seems needless to remark that parties assigned to the work of demolition should be organized with great care both as to personnel and materiel.

PRELIMINARY RECONNAISSANCE.

Whenever necessary or possible, the actual operation should be preceded by a reconnaissance made as carefully as circumstances will permit for the purpose of ascertaining exactly what means, both of men and material, will be required.

By acting too hastily in some cases, particularly in the demolition of bridges, there is danger either of using too large a quantity of explosive or of obtaining incomplete results. It is better, however, to use an overcharge than to take any chance of an undercharge.

It is unnecessary to refer here to the technical examination that should first of all be made of an extensive structure by the officer assigned to its demolition and given a fixed time to carry out the work. In this case the object of the examination is to determine the number and character of the charges to be employed, to locate the chambers for them and to ascertain what means must be provided to execute the work, taking into account the resources of the locality. It is particularly necessary that this officer should be able to recognize conditions under which the projected work would have no useful result.

Examinations of this character require special training and can properly be made only by engineer officers.

METHODS EMPLOYED.

Demolitions may be made by mechanical means, using ordinary trenching or wrecking tools, but such work requires considerable time for accomplishing any serious damage and can not be done in the presence of the enemy. Resort must therefore be had to explosives for rapid work under fire or in the vicinity of the enemy and with much less exposure of the men engaged.

The general rule is to use ordinary tools always for certain kinds of demolitions. Thus, small trees and telegraph poles should always be felled with the jointed saw. Explosives should be used for felling trees of a diameter greater than .3 meters only when there is not time to do the work with the saw or axe.

Artillery may also be used for demolitions but it is a well established fact that much time and an excessive expenditure of ammunition are necessary to so reduce the accessory works and other obstacles of the defense as to render them incapable of resisting an assault. Moreover, artillery has no appreciable effect upon other works such as heavy masonry bridges.

It sometimes happens that means are not immediately available for such a complete demolition as is desirable. This should not, however, interfere with the execution first of such damage as is possible with the means at hand in order to at least delay the passage of the enemy for some time while bringing up or awaiting the arrival of the facilities for completing the work.

Fire may also be used to destroy harvests, houses and wooden bridges, but it should be resorted to only in special cases and under particular conditions.

Since engineer troops receive thorough theoretical and practical training in carrying out demolitions, the subject will be given consideration more from the point of view of the work of infantry and cavalry.

Nevertheless, it seems useful and necessary to consider in a general way the methods employed by technical troops in order that, should the occasion arise, tactical troops may be able to understand the situation and be in a position to coöperate with the former. Above all we can not recommend too strongly that infantry and cavalry be given practical training in the preliminary operations of those forms of demolition that they will have to execute hastily. Only when men are thoroughly trained in these details, which can be done without expense, and have been repeatedly drilled in the work, can they successfully execute demolitions with the amount of explosive allowed to each corps and that would otherwise be insufficient.

CHAPTER II.

DEMOLITIONS WITHOUT EXPLOSIVES.

I. HIGHWAYS.

When it is necessary to obstruct a highway or road without the use of explosives the end can be accomplished most readily by inundations, abatis, throwing down slopes and destroying bridges.

By *flooding*, when possible, the lower parts of a road an obstacle is obtained of varying importance depending upon local conditions but this obstacle should always be utilized whenever circumstances permit.

When a road passes through a forest or is bordered by large trees, it may be rendered impassable by felling the trees on both sides so that they fall across each other over a considerable distance (several kilometers), care being exercised to leave the trunks of the trees attached to the stumps.

A considerable obstacle may also be produced by barricading a road with heavily loaded wagons and other similar objects that may be collected and confusedly heaped together at a suitable point. The burning of houses along a narrow street that can not be avoided will also cause some delay.

Simple trenches will only cause a temporary interruption of traffic, of perhaps a few hours, unless it has been possible to make them large and numerous before the arrival of the enemy. They should, however, always be made, in default of better obstacles, and if a suitable locality is selected communication may be suspended for a period sufficiently long to permit of bringing up explosives or of carrying out large demolitions in the rear. Interruptions of this character, which can be made with ordinary tools and can be readily repaired for our own use of the road, can not fail, if frequently repeated, to require some time in repairs by the enemy, particularly as it is often possible to hinder such repairs by our own fire.

Trenches in cuts should be made at the high points of embankments and in low places where they can be flooded. They should be distributed from point to point along the road and are usually from 5 to 10 meters [16 to 32 feet] wide and 3 to 5 meters [10 to 16 feet] deep, the earth being scattered as much as possible in order to increase the difficulty of refilling them. Twenty men provided with picks and shovels can, in five hours, dig a trench 4.5 meters [15 feet] wide at the top and 3 meters [10 feet] deep across a road 8 to 10 meters [26 to 32 feet] wide.

It is evident that much time and work are necessary to accomplish serious damage in this manner and resort should preferably be had to a mine.

When the road is on a hillside, landslides or slips may be produced on each side of the road. The side slopes of deep cuts may be thrown down and the road interrupted for some distance but this method requires much time and is of value only when it is not possible to go around the obstruction.

TIMBER BRIDGES.

Timber bridges may be burned as it will usually require too much time to demolish them. For this purpose petroleum or tar should be sprinkled on the principal truss members or inflammable material should be securely fastened to them or placed upon the flooring, so as to certainly burn the principal wooden members. Fire is moreover, the best means of destroying timber bridges since all the pieces that are reached by the flames are useless for repairs.

OTHER BRIDGES.

Ponton bridges may either be burned by placing inflammable material in the boats, or sunk by loading them with stone after making holes in their bottoms and breaking the roadway, cutting the anchor cables as the bridge sinks.

The cables of suspension bridges may be cut with an axe or cold chisel. Masonry and iron bridges can be destroyed only by explosives.

II. RAILROADS.

METHODS OF DEMOLITION.

If explosives are not at hand or if there is plenty of time, railroads may be obstructed for some hours, and often for several days, by damages that will either cause the wreck of a train or suspend traffic over the line.

Damage may be done either to the track, stations or rolling stock. Damages to the track, especially to important bridges, are the most serious but no sort of damage should be omitted. Demolitions at stations are also of importance as they affect the parts of the track and materiel that are most difficult of replacement. According as more or less time and means are available, the work becomes either a methodical demolition or is confined merely to hastily cutting the line and interrupting traffic.

TOOLS NECESSARY.

In all cases, in addition to the picks and shovels necessary for uncovering the ties, the men should be provided with special tools that may be obtained from the stations or requisitioned from the inhabitants. The most necessary tools for such work are common or monkey wrenches for removing fish-plate bolts; socket wrenches for removing chair bolts; spike-mauls, claw bars, hammers and sledges, cold chisels and axes.

METHODICAL DEMOLITIONS.

Demolitions of this character are of value only when they extend over a considerable length of track and include both lines of a double track road. Moreover, it is generally better to cut the line in two places than to concentrate all the work at one point.

Curves, high embankments, viaducts, tunnels and deep cuts should be selected as the points for destroying the track.

Rails may be torn up in two ways, depending on the system followed in building the road. Switches are destroyed by taking them apart. When the rails are double-headed the wedges are driven out with a hammer and the rail may be forced from the chair by using the claw-bar as a lever. Or preferably, the external jaw of the chair may be broken by striking it with a sledge, perpendicular to the rail, which can then be easily withdrawn.

If the rails are tee-headed the fish-bolts are removed with a wrench or broken with a hammer. A hole is then dug in the ballast to uncover the rail bolts which are then drawn out with the claw-bar or broken off. When this work is completed the rails are lifted out, using one man per linear meter.

If the material can be carried off the enemy is prevented from re-using it and, at the same time, it may be of use to the destroyers.

One hundred and fifty men and a train of 25 cars are required for tearing up and loading one kilometer [3,280 feet] of track per hour.

If the material is not to be removed, the ties are torn up, placed in a pile and burned after the rails have been removed. The rails are rendered useless by heating them over a fire so that they will bend of their own weight or, after heating them, they are thrown down the slope, if the track is on an embankment. They may also be either buried in the ground or sunk under water.

RAPID DEMOLITIONS.

To make a quick cut in a line, a rail is removed from each end of the section to be destroyed and the ballast is removed from the ties. A number of men, placed all on one side of the track, then take hold of the rail and the ends of the ties and turn the section upside down. An embankment should be selected for this work and the track thrown down the slope.

A hasty obstruction may be made by removing the fish-plates from two joints opposite each other and then shifting the two ends of the track laterally in opposite directions. Switches are destroyed by breaking the lighter parts and especially the operating levers and stands.

DERAILMENTS.

For the derailment of a train a point should be selected in a deep cut at a distance from a station. Derailments may be accomplished in various ways.

1. If pressed for time, it will be sufficient to remove the chair wedges or the outside bolts of T rails for a distance of about 50 meters. The same result may be obtained by sawing or cutting in two the cross-ties or by breaking off with a sledge the heads of the spikes for a distance of at least 10 meters. On a tangent the transverse oscillations of the train may cause the overturning of the rail but it is better to make the derailment certain by spreading the rails.

2. The track may be obstructed in a deep cut on a curve, in order to stop a train at night, by heaping up fallen trees, timbers, and masses or large blocks of stone covering a space of at least 3 meters to a depth of about 1 meter.

3. The surest way of causing derailment is to make a false or derailing switch on the main line as shown in Fig. 1, Plate I. To do this the upper layer of ballast is removed from the track for a rail's length and two opposite joints are disconnected in the track upon which the train is expected. The disconnected length of track is then swung out of line laterally about .3 meters [12 inches], pivoting upon the two adjacent joints, and the ballast is replaced in order to leave as little trace as possible of the work.

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Curves, high embankments, viaducts, tunnels and deep cuts should be selected as the points for destroying the track.

Rails may be torn up in two ways, depending on the system followed in building the road. Switches are destroyed by taking them apart. When the rails are double-headed the wedges are driven out with a hammer and the rail may be forced from the chair by using the claw-bar as a lever. Or preferably, the external jaw of the chair may be broken by striking it with a sledge, perpendicular to the rail, which can then be easily withdrawn.

If the rails are tee-headed the fish-bolts are removed with a wrench or broken with a hammer. A hole is then dug in the ballast to uncover the rail bolts which are then drawn out with the claw-bar or broken off. When this work is completed the rails are lifted out, using one man per linear meter.

If the material can be carried off the enemy is prevented from re-using it and, at the same time, it may be of use to the destroyers.

One hundred and fifty men and a train of 25 cars are required for tearing up and loading one kilometer [3,280 feet] of track per hour.

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For the derailment of a train a point should be selected in a deep cut at a distance from a station. Derailments may be accomplished in various ways.

1. If pressed for time, it will be sufficient to remove the chair wedges or the outside bolts of T rails for a distance of about 50 meters. The same result may be obtained by sawing or cutting in two the cross-ties or by breaking off with a sledge the heads of the spikes for a distance of at least 10 meters. On a tangent the transverse oscillations of the train may cause the overturning of the rail but it is better to make the derailment certain by spreading the rails.

2. The track may be obstructed in a deep cut on a curve, in order to stop a train at night, by heaping up fallen trees, timbers, and masses or large blocks of stone covering a space of at least 3 meters to a depth of about 1 meter.

3. The surest way of causing derailment is to make a false or derailing switch on the main line as shown in Fig. 1, Plate I. To do this the upper layer of ballast is removed from the track for a rail's length and two opposite joints are disconnected in the track upon which the train is expected. The disconnected length of track is then swung out of line laterally about .3 meters [12 inches], pivoting upon the two adjacent joints, and the ballast is replaced in order to leave as little trace as possible of the work.

When the road is double tracked, the party should be acquainted with the directions in which trains are run in order to so locate the work that no disturbance of the parallel track will be noticeable before the train reaches the point of derailment. (Fig. 2, Plate I.)

4. The removal of a rail may be sufficient and is quick and easy of execution but it is not certain in results on account of the visibility of the break.

5. Mines or fougasses, to be exploded by the passage of the train, may be used.

DEMOLITIONS AT STATIONS.

At ***stations*** the switches are broken by removing the bolts that secure the levers to the stands and movable rails; the mechanism of signal towers is destroyed; the gearing of turntables is bent or broken; and the essential parts of the water supply are removed or broken.

A ***locomotive*** may be disabled by breaking or dismantling the feed-water connections and injectors and by disabling the connecting rods and cylinders, bearing in mind that these parts are in duplicate and that both sets should be destroyed. To do more serious damage, the fire box is burned by forcing the fire without filling the boiler or after opening the blow-off valve located under the cylindrical part of the boiler.

To render a ***tender*** unserviceable the stem of the feed-water valve is removed or broken. It should not be forgotten that each tender is supplied with a set of tools including jackscrews, monkey wrenches, miscellaneous wrenches for the nuts on connecting rods, cylinders and injectors, sledges, hammers, etc.; and that these tools can be advantageously used for demolitions.

Water tanks and all the appliances used for supplying water to engines, are destroyed as completely as possible, since a railroad is rendered useless when the locomotives can not be supplied with water.

The destruction in railroad yards may be completed by burning the rolling stock that can not be removed, as well as all stores of coal, grease and oil, etc. The burning of stations should not, however, be permitted since no military advantage is gained thereby.

It is, moreover, generally useless to destroy rolling stock. It is sufficient to carry off or destroy the more fragile parts and particularly those parts that are most difficult to replace or assemble.

III. TELEGRAPH LINES.

MEANS EMPLOYED.

Iron nippers, cutting pliers, picks and shovels, are the only tools necessary for the destruction of telegraph lines. At stations the instruments

Plate I.

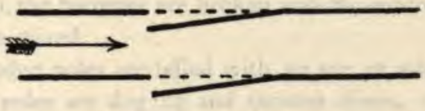

Fig. 1.

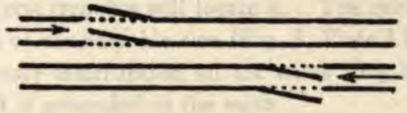

Fig. 2.

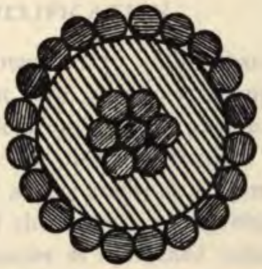

Fig. 3.

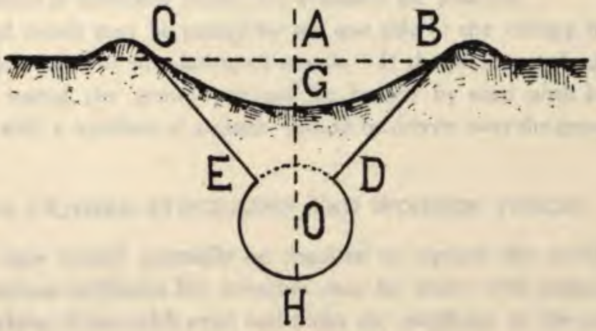

Fig. 5.

are removed or broken, the batteries are broken and the records, including copies of messages, are seized.

Along the line, wooden poles are felled with an axe or saw, preferably around curves. Iron poles are dug up and thrown down. The wire is then cut with axes or pliers and removed as far as possible. The insulators should also be broken.

If the line is underground, it will usually be found under one of the footpaths or just outside the ends of the cross-ties and at no great depth—1 meter. A few transverse trenches will locate it. The cable is cut with a carpenter's axe as it is of considerable size (Fig. 3, Plate I).

To produce a temporary interruption all the wires may be connected together by another that is grounded in the earth.

This may be very quickly done but it permits of the easy reëstablishment of communication.

IV. ACCESSORY DEFENSES.

NULLIFICATION.

It is sometimes more advantageous to nullify than to destroy certain obstacles, especially those that form accessory defenses such as abatis, sharpened stakes, wire entanglements, military pits, fougasses, etc.

Indeed, the work necessary for their destruction, while very simple, requires considerable time and is very deadly as it must be executed under the rapid and effective fire of the defense. Therefore, it will often be better to overcome such obstacles as sharpened stakes, harrows, abatis, crowsfeet, etc., by covering them with boards, hurdles, fascines, and bundles of straw or grass. It is true that a large quantity of these materials would be required to render passable a zone of such obstacles of any considerable width and length but troops should be trained to use this expeditious method if sufficient means are available for practice.

Fougasses and mines may be passed by on one side or the enemy may be induced to fire them by simulating an attack. If the presence of automatic mines is feared, the ground should be beaten by men with long poles or, better still, a number of animals should be driven over the ground in front.

PALISADES, FRAISES, STOCKADES AND WOODEN FENCES.

Too much time would generally be required to uproot the posts of palisades and various stockades but breaches may be made with sufficient rapidity by breaking down with axes and picks the planking or the posts and crosspieces that support it. Breaches may also be made with saws unless it seems preferable to throw down the posts with bars or ropes after having loosened the earth around their butts.

It is, however, more expeditious to use explosives in all cases.

ABATIS.

After withdrawing the stakes that fasten the abatis together and to the ground, these obstacles may be removed either by hand or with the aid of ropes. A passage may also be made by cutting out the most troublesome branches with axes.

WIRE ENTANGLEMENTS.

The simplest method is to cut the wires with nippers or pliers. They may also be cut with axes and bill-hooks where wrapped around the posts but this method of demolition requires much more time than the former. Good results can not be had by merely uprooting the posts.

The wire must be supported on a block of hard wood if the cutting is to be done with an axe or bill-hook.

CHEVAUX DE FRISE, CROWSFEET, HARROWS, ETC.

Chevaux de frise may simply be disconnected and removed or the pikes may be cut with an axe. Crowsfeet are swept up or gathered by hand.

Ordinary harrows, planks armed with nails and other obstacles of this character are removed after breaking their fastenings with bars, axes, etc.

SHARPENED STAKES AND MILITARY PITS.

As too much time would be required to uproot sharpened stakes with picks and crowbars, it is better to overcome them with a covering of hurdles or hay. They may, however, be cut off with axes or broken down with axes, picks, hammers, etc.

Military pits are made passable by covering them with hurdles, planks, gates, etc. It is, moreover, easy to cross them without any preparation if the artillery has even slightly disturbed the ground where they have been placed.

V. WAR MATERIAL, WALLS, ETC.

WAR MATERIAL.

To disable cannon the breach blocks or their most important parts should be carried off or destroyed. The sights, both on the gun and its carriage, are also destroyed.

Plate II.

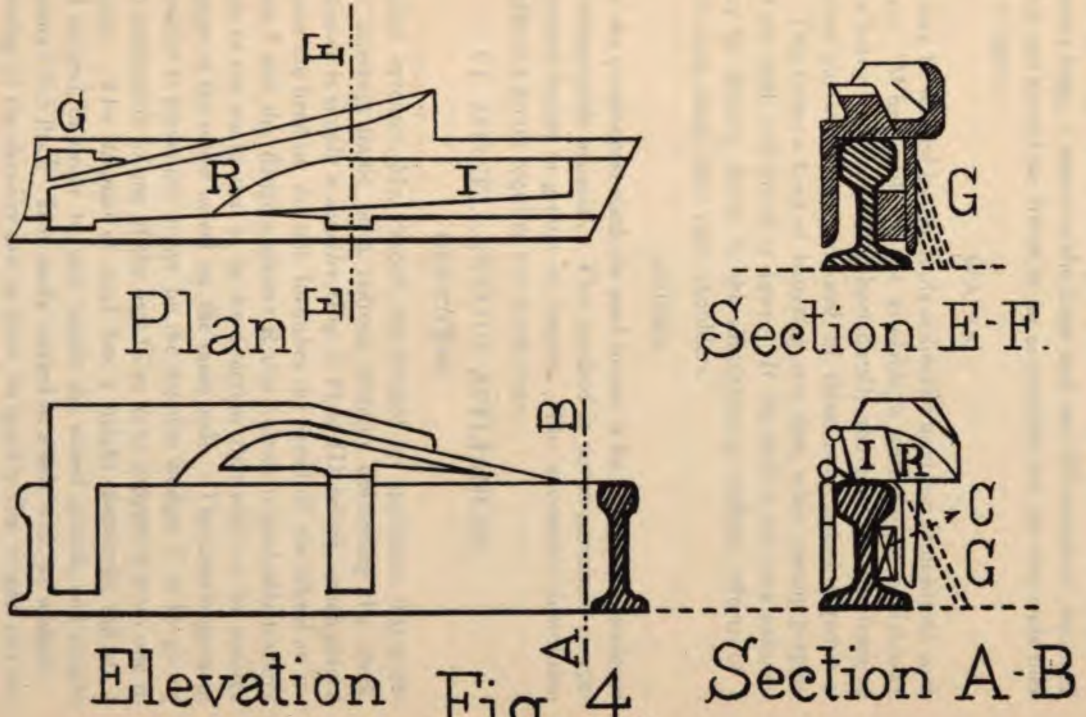

Fig. 4.

A gun may be *spiked* by driving into the vent a conical or pyramidal nail .2 meters long, .1 meter at the large end and .05 meters at the small end. This nail should be driven as far as possible and the two ends then clinched or upset.

WALLS.

Walls may be leveled by the tools ordinarily used for demolitions such as picks, etc. When tools are not available, a wall may be overthrown by using a heavy beam suspended horizontally above the ground from an extemporized gin or tripod composed of three poles lashed together at the top. This forms a kind of battering ram that, when swung perpendicular to the wall, will knock it down. If the wall is not very substantial it may be thrown down by the simultaneous rocking efforts of a number of men, using their right shoulders.

HOUSES.

One of the commonest methods used in war is by fire, using petroleum or other inflammable material. This method is never permitted excepting for isolated houses or groups of houses. The successive demolition of the walls of a house requires too much time.

VI. MISCELLANEOUS APPLIANCES.

DERAILERS.

An Italian inventor, Mr. Pascoli, has devised an appliance that is designed to interrupt traffic on a railroad without destroying the track. This appliance is simply a *derailer* (Fig. 4, Plate II), which, when placed astride upon the head of the rail, furnishes the tread of the wheel an inclined path I and the flange a groove R that carries it gradually towards the outside of the track; that is, in the direction that will not be resisted by the flange of the other wheel on the same axle. The disarrangement of the *derailer* is prevented either by the wooden wedges C or by giving a suitable inclination to one of the legs G so as to support it from one of the cross-ties. The *derailer* of steel has a height above the rail of .1 meters [4 inches], in order to pass under the wheel guards, and weighs 12 kilograms [26.5 lbs.]. It is easily carried in a belt with its wedges.

The setting of the *derailer* can be done so quickly that a man can put it in place immediately before the arrival of the train and thus avoid detection by the track inspectors. Moreover, with the ordinary locomotive headlight, the engineer can not detect the *derailer* at a distance of more than 40 meters, a distance that is insufficient for stopping a train having a speed of even 25 kilometers an hour.

CHAPTER III.

EXPLOSIVES USED IN DEMOLITIONS.

GENERAL PROPERTIES.

Explosive substances have the property of decomposing suddenly from shock or from their reactions upon each other, liberating an enormous quantity of gases at a high temperature.

This phenomenon, which is called ***explosion***, results in giving to the gases very high pressures, productive of violent mechanical effects that are used for demolitions in campaign. Such agents have therefore the advantage of developing great explosive powers with a minimum of weight and volume.

EXPLOSIVES IN GENERAL.

Explosive compounds are usually of organic composition and, like the substances composing them, are grouped into two series, the ***fatty series*** and the ***aromatic series.***

The fatty series of organic compounds includes the hydrocarbons, saturated or not, that produce the following explosives, viz:—

Fulminates, gun cottons, nitro-glycerine, dynamites, etc.

The aromatic series, of which the hydro-carbon, benzene, is, so to speak, the base, furnishes the explosives picric acid and the picrates (melinite, cresylite, etc.), and the panclastites.

In general, the explosives of the fatty series contain more oxygen than is necessary for the oxidation of their combustible elements while the hydrocarbons of the aromatic series are not saturated, and have always an excess of carbon, making it therefore difficult to be certain of the manner of their decomposition.

QUALITIES OF A GOOD EXPLOSIVE.

The qualities required in a good military explosive are:—

1. Permanence for an almost indefinite period.

2. Safety in manipulation and transportation.
3. Insensibility to shocks, particularly from projectiles.

FULMINATES.

The fulminates may be considered as derivatives of fulminic acid which has not yet been obtained in a separate form but in which the hydrogen is replaced by a metal. There will be considered here only the *fulminate of mercury* which, on account of its being detonated by shock, is used in the manufacture of caps, fuzes and detonators for other explosives, thus permitting the latter to be placed in a resisting envelop.

Fulminate of mercury is too violent in its action and corrodes excessively the metal of receptacles containing it. This explosive is therefore mixed with sulphide of antimony and saltpetre (for rifle caps) or with chlorate of potash (for revolver caps) to moderate its effects.

GUN COTTON.

Gun cotton is obtained by the action of concentrated nitric acid, or by a mixture of nitric and sulphuric acids, on cotton or, in general, upon cellulose such as wood, straw, paper, etc.

It is used for charging all naval torpedoes but its use by the land forces has been abandoned since its handling in large quantities is dangerous on account of its liability to decomposition.

DYNAMITES.

Dynamite is made by mixing nitro-glycerine with silica on some other inert and absorbent material, nitro-glycerine alone being extremely dangerous.

There are two general classes of dynamites, viz:—

1. Dynamites with inert bases, in which the absorbent is pure silica obtained in the vicinity of Radan (Puy-de-Dôme); hence the name, *radanites,* by which they are known.

2. Dynamites with active bases, in which the nitro-glycerine is mixed with combustible substances that absorb the excess of oxygen and increase the force of the explosion. These explosive bases are charcoal, gunpowder or its derivatives (lithofracteur), gun cotton (explosive or blasting gelatin), etc.

Dynamite is a plastic material, slightly greasy to the touch, and detonates with extreme violence when exploded by a fulminate of mercury fuze. It freezes at moderate temperatures and the nitro-glycerine has a tendency to exude from the base. This tendency is objectionable in that it makes results uncertain but more especially because it leads to accidental explosions with terrible results. For this reason radanite, which was formerly used for military purposes, has been replaced by melinite and is now used commercially only in the form of cartridges.

However, as this explosive can be readily obtained commercially and has practically the same properties as melinite it is possible that it may be levied for use when melinite is not available.

Frozen dynamite is not dangerous so long as it remains in that condition but it is more difficult to detonate. It should not therefore be thawed if it can be used in a frozen state.

MELINITE.

Melinite is obtained as a gelatinous substance, crystallized in irregular cubes, by treating with nitric acid one of the coal tar derivatives.

Its manufacture and manipulation can be carried on without danger and it is insensible to ordinary shocks, friction and atmospheric influences. It can be burned in the open air without danger and when wet is detonated with great difficulty. Melinite most nearly fills the general conditions requisite for demolitions in campaign and is used exclusively in addition to gunpowder.

Melinite detonates *instantaneously* and progressively throughout its mass. It has therefore an advantage over gunpowder in that it can be used without tamping but when so used it loses an appreciable part of its destructive effect. It is therefore desirable to cover the charge with a small amount of earth or even with a small stone and it rarely happens that there it not time for such a tamping, however hurried, as it will considerably increase the results.

Melinite, as used for demolitions, is supplied in prismatic *petards* weighing 135 grams and cylindrical *cartridges* weighing 100 grams. These petards and cartridges and the methods of using them are described further on. The artillery also uses melinite for the bursting charges of elongated steel shells, 4½ calibers in length and of large interior capacity, called *torpedo-shells.*

Melinite is used in two forms, viz:—

1. *Granular melinite*, of a light yellow color and detonated by a smaller charge of fulminate of mercury than fuzed or cast melinite. It is used for detonating charges and is itself detonated by a fuze containing 2 grams of fulminate, causing the explosion of the melted melinite within which it is placed.

2. *Fuzed melinite* is slightly more gray in color and is obtained by melting the explosive into a solid, crystalline mass. It has a specific

gravity greater than the granular form and an equal weight occupies less space. Moreover, it is easier to manufacture and to load into shells. It is therefore used for the bursting charges of torpedo-shells particularly as the detonating effects of the two forms are equal, weight for weight.

It is known that these torpedo-shells have been so effective against fortifications and shelters protected by earth that it has been necessary to change entirely the design of such works and the methods of defensive siege operations.

CRESYLITE.

Cresylite belongs to the melinite class and is obtained by the action of nitric acid on cresol.

BALISTITE, CORDITE, ETC.

Foreign artillerists use, in place of melinite, various explosives also derived from picric acid and known as ***Explosive, type of 1888***, in Germany, ***cordite*** in England, ***ecrasite*** in Austria, and ***balistite*** in Italy. ***Ecrasite***, in its latest form, is merely picric acid compressed to a density of 1.4.

PANCLASTITES.

Panclastites result from the action of nitrogen-tetroxide upon hydrocarbons such as carbon disulphide, petroleum and its derivatives, fats and their derivatives, etc.

They are called reaction explosives, since they are prepared only at the moment of use and the reaction of the two substances causes an instantaneous explosion.

VARIETIES EMPLOYED.

Service or black powder was for a long time the only explosive used in the army. In order to obtain greater explosive effects ***high explosives*** were introduced, first gun cotton, then dynamite and last of all, in France, melinite. The latter is the only mining explosive now used by the land forces.

GUNPOWDERS.

The gunpowder ordinarily used for demolitions is the MC 30 powder formerly used in smooth bore guns, and composed of 75 parts of saltpeter, 12.5 of sulphur, and 12.5 of charcoal.

The combustion of this powder produces a large quantity of gas whose expansion results in combined effects of projection and demolition. Its combustion is progressive and requires an appreciable time for completeness. In order to obtain its maximum effects, a charge must therefore be *tamped;* that is, it must be enclosed by a resisting mass that will permit of the gradual production of the gas in an enclosed space until its full expansive effect is produced.

The effect of gunpowder is small compared to high explosives, particularly if it is not well tamped. When tamped, a charge of gunpowder produces only one-third the effect of high explosives and without tamping the effect is one-twentieth. Untamped powder charges have practically no effect on iron and steel.

Moreover, great care is necessary in the handling of gunpowder in order to avoid accidental explosions. All the hammers, funnels and other tools used with it must be made of copper or bronze, to avoid sparks such as are made by blows of iron or steel tools.

It is also necessary to protect gunpowder from all moisture, the least amount of which will damage it.

COMPARATIVE VALUES OF GUNPOWDER AND HIGH EXPLOSIVES. *

Service powders are ignited more readily than high explosives but decompose much more slowly and develop much less violent pressures. For this reason they are used in firearms. Moreover, they can be exploded without employing a detonator.

High explosives, on the contrary, require the preliminary action of a detonator but on account of their extremely rapid decomposition and the greater amount of work resulting therefrom, they have a destructive power much greater than black powders.

The difference in the explosive action of melinite and gunpowder may be explained in a general way, by supposing that two charges, one of melinite and the other of gunpowder, are exploded in contact with a resisting metallic partition—a plate of iron, for example.

The very high pressures reached by the gases produced from the detonation of these substances will be greater in the mass of melinite as just stated. These high pressures will cause, the very instant they are produced, a violent rupture of the equilibrium existing between the disengaged gases and the surrounding medium. The gases will by the rapidity of their expansion, be projected against the surrounding objects with an infinitely great velocity. With melinite the blow produced by these enormous velocities will be sufficient to rupture metal plates in contact with the charge but with gunpowder, on the contrary, the useful effect upon the plate is insignificant. The result will be the same in contact with masonry.

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* This section is a resume of an article published in the ***Revue der Cercle militaire*** of July 1st, 1899.

In the case of gunpowder, the gaseous masses are merely reflected from the objects they encounter. If, however, instead of exploding the charge of gunpowder in the open air, it is exploded in a closed chamber of exactly its own volume, the result will be entirely different. At each phase of the transformation of the mass of powder into gas, the pressures produced will be added to those already existing and the total pressure will necessarily attain a higher value than in the other case. The kinetic energy thus obtained, acting as a whole upon the material composing the envelop of the charge, is most favorably situated for producing rupture.

It is evident from the preceding remarks that gunpowder can be used to advantage only when it can be placed in mine chambers closed by tamping. Some general information upon this subject will be given further on. Moreover, gunpowder is to be preferred in such cases to high explosives and if, for want of the former it becomes necessary to use melinite, the rapidity of action of the latter may lead to incomplete demolitions, with walls of varying thicknesses, since the explosive effect takes place only on the line of least resistance.

On the other hand, melinite is well suited for the demolition of iron and steel viaducts and bridges, whose members are of such small size as scarcely to permit of the introduction of mine chambers.

CHAPTER IV.

USE OF EXPLOSIVES.

IN GENERAL.

As has been previously stated, high explosives can, as a last resort, be used without tamping and in this lies their great advantage when pressed for time as, for instance, when under fire of the enemy. This method of using them is employed only against objects that offer slight resistance and it is preferable in all cases to use a tamping, however light. The fact that gunpowder is damaged by moisture should not be overlooked.

Whenever charges are placed underground or within strongly resisting materials, and particularly when gunpowder is used, it is absolutely necessary to follow certain special methods that are usually the functions of engineer troops but that should be known in a general way to all officers.

MINES.

Any charge of explosives that by its ignition produces destructive effects injurious to the enemy is called a *mine*. This charge is placed in a space prepared for the purpose and called a *mine chamber*. When the charge is in place it is known as a *charged mine*.

SYSTEMS OF MINES.

When several mines are intended to produce one general result as, for instance, the destruction of a large bridge, the entire work is called a *system of mines*.

The underground communications that must be excavated to reach the mine chambers are called *galleries*, if of large or medium size, and *branches* or *branch galleries* when of small dimensions. Vertical connections are called *shafts* when large enough for the passage of a man and *wells* or *drill holes*, when a man cannot pass through them.

Galleries, branches and shafts are lined with a sheathing of planks supported at intervals of a meter by *gallery frames*. In rock and in some very stiff earths galleries and shafts of small dimensions may be excavated without sheathing.

PERMANENT SYSTEMS.

The demolition of large masonry structures (bridges, viaducts and tunnels) is accomplished by means of a permanent system of mines prepared in time of peace. These systems consist of chambers placed in the interior of the masonry (piers and abutments) of bridges and viaducts and above the arch or behind the side walls of tunnels. Gunpowder is universally used for such demolitions.

EFFECT OF MINES.

The deflagration of a charge of explosives placed below ground that has a horizontal surface produces:—

1. *Interior Effects*, consisting first of a violent compression of the ground in the vicinity of the charge and the formation of a spherical space called the *chamber of compression*. In addition to this, the expansion of the gases produces a concussion whose destructive effects upon structures in the ground or in contact with it extend to some distance.

2. *Exterior effects*, with a full charge, are the projection of the earth upward in the form of a cone and the formation of a *crater*, more or less refilled by the earth. The mound around the edge of the crater is the rim or lip.

CALCULATION OF CHARGES.

The charge for a mine depends upon the effect that is desired and the material in which the mine is placed.

The line of least resistance (L L R), is the distance from the center of the powder O, (the mine chamber), to the nearest point on the surface, A (Fig. 5, Plate I). It is ordinarily represented by h.

When AB or r, the radius of the crater as measured at the surface of the ground, is equal to h the mine is called a *common mine*. The mine is *overcharged* when r is greater than h and *undercharged*, when r is less than h. If the mine produces no exterior result, that is, if r is equal to zero, it is called a *comouflet*. The mine constant or index is designated by n and represented by the formula $n=\frac{r}{h}$.

The powder charge for a common mine is calculated from the formula $C=gh^3$, in which C is the weight of the charge in kilograms, *b* is the line of least resistance in meters and *g* is a coefficient whose value varies with the character of the material in which the mine is located.

The principal values of *g* are 1.5 for ordinary earth, 2 for earth mixed with *gravel*, 3 for common masonry and 4 for the heaviest and best masonry.*

The above formula is known as the *miner's rule*. For overcharged or undercharged mines the formula generally used is $C=gh^3(\sqrt{1+n^2}-.41)^3$, in which *n* is the mine index or constant.

EFFECTS OF MELINITE.

As has just been stated, gunpowder is really effective and susceptible of useful employment only when well tamped. On the other hand, the decomposition of a charge of melinite takes place instantly throughout its entire mass. There is formed immediately a large amount of gas under enormous pressure. The air surrounding the charge can not be displaced with sufficient rapidity to open a passage to this gas and acts therefore so much in the same way as tamping that the latter is no longer indispensable.

Melinite may therefore be used in contact with hard bodies which it either destroys or reduces to fragments. *Contact* is indispensable but *tamping* is not, although the latter increases the effect when of even the lightest character. For this reason melinite is generally used for demolitions in campaign although gunpowder is to be preferred from the point of view of economy.

It may also be used to charge mines and its effect is similar to that of gunpowder but is three times as great for charges of equal weight.

The same interior and exterior effects are produced. Moreover, the detonation of melinite in the open air produces a heavy concussion that extends to great distances and the violent expansion of the gas in an inclosure may occasion serious destruction. This action is known as the *blast* of melinite and must be considered in permanent fortifications.

DRILLED OR BORED MINES.

Drilled or bored mines are cylindrical holes of various diameters

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*In the formula $C=gh^3$, if C represents the charge in *pounds* and *h* the line of least resistance in *feet*, the values of *g* become .31 for ordinary earth, .41 for clayey gravel, .62 for common masonry and .82 for the best masonry.—Translator.

according to the tools used. An explosive charge is placed at the lower end, either in the hole itself or in an enlarged chamber.

Drilled mines of small diameter may be of great service, especially with the aid of Major Binet's mine drill .06 meters [2.36 inches] in diameter. This tool (Fig. 6, Plate III), is composed of a steel drill point that is cross shaped for firm soils and has a conical point for loamy material. The drill points are fitted to a drill head into which are screwed, one above the other, hollow extension rods of steel 1 meter [39.37 inches] long and fitted with screw couplings.

The tool is used in the same way as an ordinary mine drill, giving it at the same time a slow motion of rotation. In clayey soils holes may be driven easily to a depth of 12 to 15 meters [40 to 50 feet] at a rate of 5 to 8 meters [16 to 26 feet] an hour. Under very favorable conditions this rate may be 1 meter in two minutes.

A chamber may be made at the end of the hole by inserting several melinite cartridges attached to the end of a small rod and exploding them to form a chamber of compression. If, instead of placing this charge of melinite at the end of the rod, it is extended over a part of the hole vertically, an elongated chamber is formed or even a shaft, if the charge extends to the surface.

The mine is charged by pouring granular powder directly into it if the slope of the hole is greater than 1 to 1. If the hole has a flat slope, a brass tube is inserted and through it are forced a number of powder or melinite cartridges not greater than .03 meters [1.18 inches] in diameter, using a jointed brass rammer. When the hole slopes upward a rammer with a head of the same diameter as the interior of the brass tube is used. The detonation of the charge is generally produced by a melinite cartridge placed in position by the rammer whose head has a groove to accommodate the fuze wires. Tamping is, in general, unnecessary.

It is evident that mine chambers can be very rapidly obtained in this way, since a kilogram [2.2 lbs.] of melinite will make a chamber large enough to contain 850 kilograms [1870 lbs.]. An embankment can thus be destroyed in a few minutes so as to cut a highway or railroad. In the same way bridge abutments, tunnels and houses may be destroyed very rapidly by placing one or two charges in the abutments, arches or foundations.

Drilled mines can be frequently and advantageously used in demolitions and it is to be regretted that they require a special tool. Infantry and cavalry pioneers should be instructed in the use of the

Charges are considered as *elongated* only when they have a length at least 4 or 5 times the diameter of a circle equal to their cross sections.

Concentrated charges are generally employed and, when gunpowder is used, they are placed in cubical boxes or in chambers whose shape is as nearly cubical as the conditions of the work will permit. Elongated charges are made up of cartridges, enclosed in tarred sand bags, that are placed in the recess preparted for them.

ARRANGEMENT OF CHARGES.

Melinite charges, either concentrated or elongated, are ordinarily made up of model 1886 petards or the model 1890 cartridges that have been described previously. In preparing concentrated charges the petards or cartridges are brought into close contact with each other and made up by straps or any other kind of lashing into packages or bundles that should be as nearly as possible the shape of a cube. The petards or cartridges may also be enclosed in a canvas or cloth sack. In elongated charges the petards or cartridges are placed end to end, either singly or in small bundles, depending upon the weight of the charge per linear meter. In fact, the successive parts of these charges may be placed in cloth or wooden tubes, lengthwise on small rods, in troughs or merely in the hole made in the body to be destroyed. Care should be taken to place this work in the hands of men specially trained for it in order to avoid the breaking up to which such charges are liable.

A charge composed of petards should always be made up in such a way that the faces of the petards are in contact and it should be remembered that the maximum effect is produced when the relation of the length to each of the other dimensions is as 5 to 1. Petards placed in contact with an object to be demolished, should be applied as closely to it as is possible.

FIRING DEVICES.

Explosive charges may be ignited either by pyrotechnic compositions or by electricity.

PYROTECHNIC METHODS.

Under this method ignition is brought about by pyrotechnic compositions that are of slow or rapid combustion.

When gunpowder composes the charge the composition ignites the powder directly, but when the charge is of melinite the composition explodes a *fuze* that detonates by simple ignition and thus detonates the charge of melinite in contact with it.

The *fuze* or *detonator* is a brass tube closed at one end (Fig. 7, Plate III). It is 45 millimeters [1.77 inches] long, 6 millimeters [.24 inches] in diameter and contains 1.5 grams [23.14 grains] of pure fulminate of mercury. The charge is held in place by a small brass cap with a small central opening that is closed with a drop of varnish to protect the fulminate from moisture. The part of the tube that contains the fulminate is shown on the outside by a coat of black paint.

SLOW FUZES.

The only fuze of this kind that is provided for in departmental instructions is the *slow fuze* or *Bickford safety fuze*, a commercial article. This fuze consists of a cord composed of two layers of tarred thread wound spirally one upon the other but in contrary directions, in the center of which is formed a tubular opening 3 millimeters [.12 inch] in diameter, filled with fine powder well compressed into a continuous core [Fig. 8, Plate III]. Its external diameter is 5 millimeters [.2 inch].

It burns at the rate of 1 meter in 90 seconds. Its length is made sufficient to enable the operator to retire to a safe distance. Generally 1 meter is ample for this purpose since it is possible to run 200 meters before the fuze burns out.

When the fuze is to remain for some time in the ground or under water a *submarine* fuze is used that differs from the ordinary Bickford fuze only in the addition of a rubber envelope or a covering of waterproof varnish.

Ignition of Bickford fuzes.—To easily light the Bickford fuze the end should be cut on a bevel or should be split and the two halves seperated without letting the powder fall out. To the powder, thus laid bare, is then applied a piece of lighted tinder or coal, a lighted cigar, etc.

Igniters.—If the contact of the igniting body with the powder of the Bickford fuze is not good, ignition will not take place. This difficulty is avoided by using the Bickford portfire or tinder.

The *Bickford portfire* consists of a cylinder, 4 to 5 millimeters in diameter, of thin blotting paper tightly rolled and steeped in a solution of acetate of lead. It burns at the rate of about a centimeter [.4 inch] per minute.

Tinder is a braided cotton cord impregnated with chromate of lead. It burns at the rate of .4 meters [15.75 inches] per hour.

It is better, however, to use the *Ruggieri fuze* or igniter (Fig. 9, Plate III) which is placed over the square-cut end of the Bickford fuze. This iginter is formed of a small copper cap containing a combutsible composition that is traversed by a piece of quick match. The latter extends outside the cap and is easily lighted.

QUICK FUZES.

The only quick fuze actually authorized is the *detonating fuze*.

This fuze is composed of a core of granular melinite contained in a pewter envelope (Fig. 10, Plate IV). It has the form of a tube whose external diameter is 5.5 millimeters [.22 inch] and corresponds to the internal diameter of the detonator used with melinite petards. It weighs about 100 grams per linear meter [.2 lb. per linear yard] and is pliable to such an extent that it may be bent in any direction, care being taken in all cases not to twist it too violently or abruptly.

This fuze can only with great difficulty be ignited by contact with a lighted body and its combustion ceases without producing the explosion of the detonating fuze.

To detonate it, the fuze is cut square, so as to lay bare the dry part of the melinite core, and the end is then capped with a fulminate of mercury detonator. The black portion of this detonator is secured against the black portion of a second detonator that is primed with Bickford fuze (Fig. 11, Plate IV). This black portion indicates the length occupied by the fulminate.

The detonating fuze may also be fired by the explosion of a melinite petard. In this case care must be taken to secure the end of the fuze to the petard along the full length of the latter.

The *rate of detonation* of this fuze is about 2000 meters per second and it may therefore be considered as instantaneous.

To prime a melinite petard with the detonating fuze the end of the latter is inserted in the fuze chamber and secured in place by a lashing of twine. To produce the expolsion of several petards placed in a row but at a distance from each other, the first is primed and then each petard is connected with the following one by a detonating fuze that is lashed for the full length of the first and is inserted to the bottom of the fuze chamber of the second.

To produce the simultaneous explosion of several mines, grouped in any way, they should all be prepared with detonating fuzes, whose lengths need not be measured on account of the rapidity of detonation of this type of fuze. At the desired time the free ends of the fuzes are brought together and fired.

Great care must be exercised to prevent detonating fuzes crossing each other or forming loops at a distance less than .2 meters [8 inches] since the explosion of the first strand will cut the second at the point of intersection and the detonation will not be transmitted further.

The same thing will happen in case the fuze A B D is bent back upon itself in the neighborhood of two detonators A (Fig. 12, Plate IV) joining this fuze to a Bickford or to a detonating fuze A G designed to transmit the explosion to B D. The explosion will be stopped at the point D which will be cut by the explosion of the fuzes A.

Instantaneous Fuze.—Mention should be made of the quick fuze that was in use previous to the detonating fuze and known as the *instantaneous fuze.*

This fuze is composed of three strands of quick match bound together by a strip of waxed linen, the waxed side inside, and covered with a helical wrapping. Outside of the latter is a layer of natural rubber and, finally, a braided covering. Its rate of combustion is 100 meters [390 feet] per second.

Powder Hose and Powder Train.—When other fuzes can not be had these primitive means may be employed. The *powder hose* is a linen tube 15 to 25 millimeters [.6 to 1 inch] in diameter and filled with powder. It burns at the rate of 3.5 meters [11.5 feet] in the open air and 8.5 meters [28 feet] in a hose trough. A *train of powder* placed upon a board burns at the rate of 2.5 meters [8 feet] per second.

DISADVANTAGES.

All the preceding pyrotechnic methods have the disadvantage of producing smoke in the galleries and of not causing an instantaneous explosion. When they are used it is therefore necessary to wait a considerable length of time after the fuze has been lighted before the mine can be entered either to allow the smoke to escape or to seek the cause of a misfire.

ELECTRICAL METHODS.

GENERAL PRINCIPLES.

When possible to do so it is always better to ignite explosives of all kinds by means of an electric current that is passed through a special fuze placed in contact with the explosive.

The electrical method requires the installation of conductors connected at one end to the source of electricity and at the other to the

Plate IV.

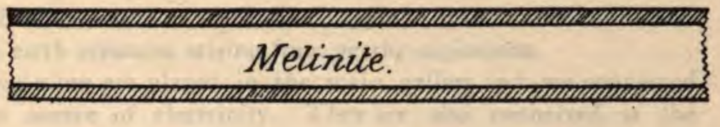


Fig. 10.

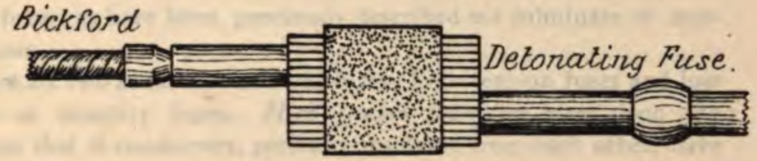


Fig. 11.

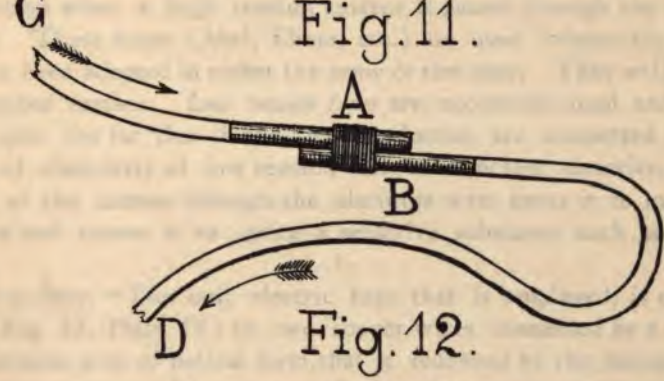
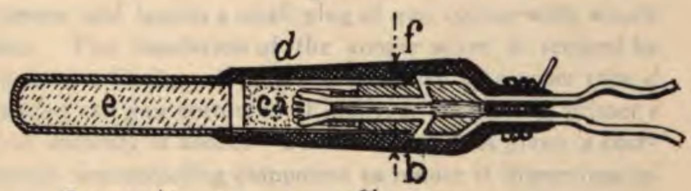
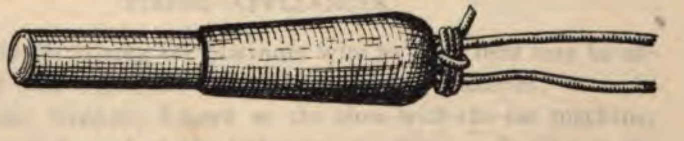


Fig. 12.



Longitudinal Section.



Perspective View.

Fig. 13.

fuze. These conductors are iron or copper wires of sufficient size to resist the earth pressures arising from nearby explosions.

The *lead wires* are placed in the main gallery and are connected with the source of electricity. They are also connected, at the proper time, to the *branch wires* or to the special wires of any mine.

When the electrical method is employed to fire melinite it is necessary to make the same arrangements for the connection of the petards to the fuzes, as have been previously described for fulminate of mercury fuzes.

There are two kinds of electrical fuzes; high tension fuzes and low tension or quantity fuzes. *High tension fuzes* are based upon the principle that if conductors, perfectly insulated from each other, have their ends brought near enough together a spark will be produced between them when a high tension current is passed through the conductors. These fuzes (Abel, Ebner, etc.) are used industrially but have not been adopted in either the army or the navy. They will not be described further. *Low tension fuzes* are exclusively used and are based upon the fat that if the two conductors are connected to a source of electricity of low tension but of sufficient quantity, the passage of the current through the platinum wire heats it to incandescence and causes it to ignite a sensitive substance such as gun cotton.

Electric Fuze.—The only electric fuze that is employed, is composed (Fig. 13, Plate IV) of two copper wires connected by a very fine platinum wire of helical form that is reddened by the passage of the electric current and ignites a small plug of gun cotton with which it is in contact. The insulation of the copper wires is secured by imbedding them in a hard wood plug *b* surmounted by a paper tube *d* in which is placed the gun cotton *c*. Finally, a detonating primer *e* of fulminate of mercury is added. The whole plug is given a coating of Chatterton waterproofing compound to render it impervious to moisture.

FIRING APPLIANCES.

The current for raising the platinum wire to a red heat may be obtained either from induction machines or primary batteries.

The *Breguet Exploder*, known as the blow-with-the-fist machine, is the most widely used of the induction machines. Besides being very simple and essentially portable it has also the advantage of requiring no liquid (Fig. 14, Plate V). It utilizes the induced current formed by the sudden withdrawal and replacement of the armature of a powerful magnet. To fire a charge, the two conductors are connected to the terminals of the machine, the safety catch is withdrawn and, at a given signal, it is only necessary to strike a blow with the hand upon the spring handle.

Siemens and Halske have designed, for military use, an *exploder* that produces tension effects (sparks) instead of the quantity effects (incandescence of platinum wire) given by their ordinary machine. The wire in the coils is rearranged and the current passes through the exterior circuit, of which the fuze is a part, only when the circuit is broken by the movement of a cam (Fig. 15, Plate VI).

For a long time the *bichromate* or *plunge battery* was used in the engineer service to produce electric sparks. It is composed of a cylindrical exterior cell of gutta-percha and a cylinder *B* of the same material, called the plunging cylinder or merely the plunger (Fig. 16, Plate VI). The latter has on its upper end a copper ring A for handling and two copper binding posts *b b* that form the positive and negative poles. Four cylindrical chambers open upwards from the base, each of them being lined with a sheet of amalgamated zinc to within 10 millimeters [.4 inch] of its orifice and containing, in addition, a rod of carbon placed axially. These four zinc-carbon elements are rigidly attached to the inside of the plunger. The exciting liquid commonly used is a mixture of four parts of chloro-chromate of potassium (yellow salt) and ten parts of bi-sulphate of potassium (white salt) dissolved in 120 parts of water.

To bring about the explosion, the conductors (attached to the wires of the electric fuze) are connected to the two poles *b b* of the battery plunger and the latter is plunged into the exterior cell containing the exciting liquid. The contact produces it.

These cells have been replaced by an induction machine of easy manipulation that is called the *Boulanger exploder* and furnishes high tension currents. This exploder is a magneto-electric machine composed of an induction coil that revolves about a vertical axis and between two pole pieces attached to electro-magnets. The coil is rotated by pulling on a cord that has previously been wound around the axis of the coil. The cord should be drawn out at only a moderate speed in order to avoid the danger of burning out the platinum fuze wire and thus causing a misfire.

The old bichromate battery will fire one fuze to distances as great as 900 meters or two fuzes at a distance of about 400 meters. The

Plate V.

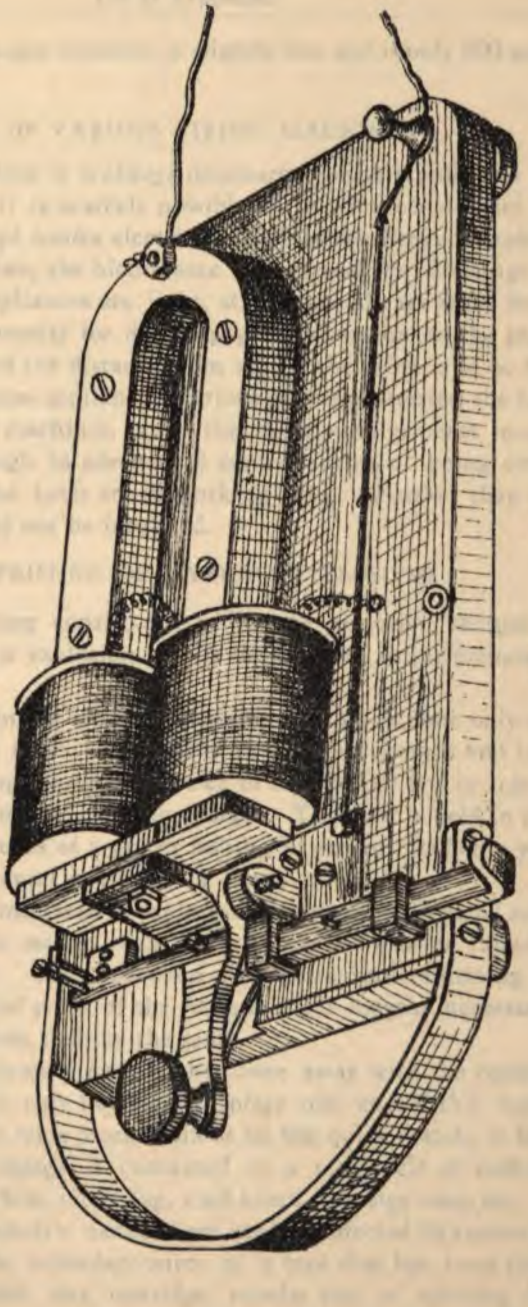


Fig. 14

range of the Boulanger exploder is slightly less and is only 300 meters for two fuzes.

USE OF VARIOUS FIRING MACHINES.

In campaign, where it is always necessary to work rapidly and with little preparation, it is scarcely possible to use machines other than those producing ***high tension*** electricity, such as the Breguet exploder, the Siemens machine, the bichromate battery and the Boulanger exploder. These appliances are light, strong and always ready for use and obviate the necessity for devoting great attention to the perfection of contacts and the distance from which the mine is to be fired.

With all ***low tension*** appliances (various primary batteries, the Ladd, Siemens, Gramme machines, etc.), the firing arrangements must be prepared long enough in advance to permit always of being certain that the circuits and fuzes are in working order. Further than this, the conductors need not be insulated.

THE PRIMING OF VARIOUS EXPLOSIVES.

Principle.—Priming consists in adding to explosive charges the means of ignition or explosion. It is the first step in the preparation for firing.

Gunpowder.—Priming with pyrotechnic methods is done only with the Bickford safety fuze. The end of the fuze is trimmed and introduced into the charge through the side of the powder box or into the receptacle containing the priming charge. This end is held in place in the charge by means of a pin or lashing to prevent its being withdrawn by any accidental strain on the fuze.

To obtain the simultaneous explosion of several charges by means of the quick fuze or match, resort must be had to what is called the ***equalization of fuzes.*** This operation consists in so determining and regulating the initial point of the fuzes that the lengths necessary to reach all of the mines shall be the same.

The use of the detonating fuze has done away with the equalization of fuzes. It is only necessary to place one end of this fuze in the charge with the same precautions as for the quick match, it being assumed that the charge is contained in a receptacle of sufficient strength, such as a box, cloth bag, card board cartridge case, etc.

Priming, when electric methods are used, is effected by connecting up the ends of the secondary wires of a fuze that has been placed either in the powder box, cartridge, powder bag or priming box.

This method of priming permits of firing exactly at the desired moment.

Melinite.—To explode a whole charge of melinite it is only necessary to detonate one of the petards composing it. This petard is called the *primer* and may be detonated by either pyrotechnic or electric methods.

Pyrotechnic priming may be done with either the slow fuze or the detonating fuze, according as it is desired to fire from nearby or from a distance.

Priming a Detonator.—A detonator is primed by inserting within the tube an end of slow fuze that has been cut square and well cleaned. The slow fuze is pushed into good contact with the fulminate and the edge of the detonator is compressed with a pair of pliers so as to hold the fuze in place without choking it.

Priming a Melinite Petard.—To prime a melinite petard, the wire strip is removed and consequently the pewter cover so as to expose the fuze chamber, into which is thrust the tube of a detonator. Care must be exercised not to suspend the petard by the fuze as it is indispensable that the detonator remain firmly in place at the bottom of the fuze chamber.

It is possible that the reaction of the detonator may force it from its chamber at the instant of detonation and it is therefore desirable to secure it to the petard by a lashing as shown in Fig. 17, Plate VI, or to maintain it in its place in the chamber by a small wedge pressed in gently and without the use of force.

Priming with the detonating fuze is executed in the same way as with the slow fuze. The use of a detonator with this fuze is not, however, absolutely necessary. The explosion of a detonating-fuze, whose end has been pushed home to the bottom of the detonator chamber of a petard is sufficient to initiate the detonation of the latter. The same result can generally be accomplished by merely applying the detonating fuze to the exterior of the petard in the direction of the greatest length of the latter and by firmly lashing it in place.

The *electric priming* of a melinite charge is secured by attaching the electric fuze to the end of the cables leading to the exploder, using the wires connected to each cable. The fuze is then placed in the priming petard or cartridge and the latter is firmly secured to one of the charges of explosives.

Charges of Several Petards.—The explosion of a charge composed of any number of petards is always assured by the detonation of a single

Plate VI.

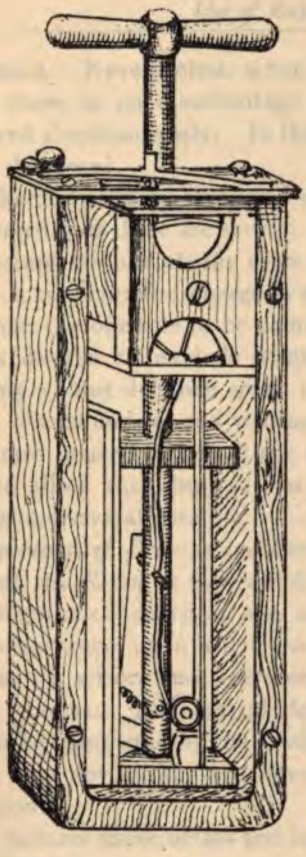


Fig.15

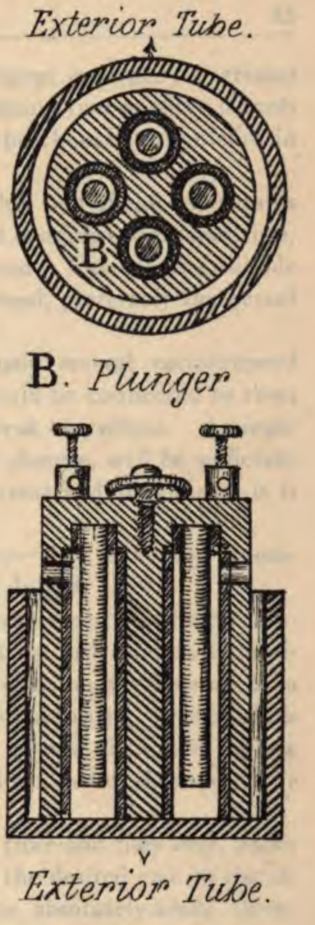
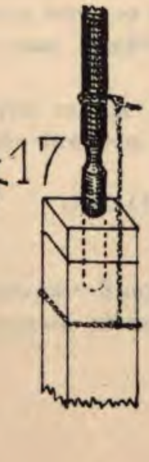


Fig.16

Fig.17



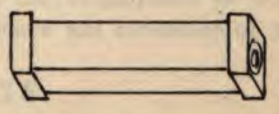


Fig.18.

primed petard. Nevertheless, when the charge is large, for greater certainty, there is no disadvantage in priming two or three petards that are fired simultaneously. In this way the chances of a misfire in a fuze are decreased.

When the charge is an elongated one, either one of the end petards may be primed. If there are several rows of petards in juxtaposition, the end petard of one of the rows is primed. One of the outside petards of a concentrated charge is also primed, preferably the petard farthest from the obstacle to be demolished.

If it is desired to explode simultaneously several concentrated charges only a short distance apart, they should be connected by rows of petards placed end to end without a break anywhere. A single primed petard, placed in one of the outside charges, will be sufficient to detonate all of them but, as has been remarked previously, it is better to prime several petards.

The Importance of Priming and Connections.—The following quotation is from the *Revue de Cercle militaire* of July 8, 1899:

"Priming and connections play an important part in the preparation of mines since upon their good working order depends simultaneousness of action and, therefore, the maximum efficiency of a system of charges. The partial demolition resulting from misfires must often be completed by the installation of new charges to replace those that have not ignited and have been dislodged or thrown out by the explosion.

"Such failures cause delays and losses of time and they may, above all, result in preventing the attainment of the desired end in the allotted time. It is important, therefore, to absolutely avoid them. To this end, the proper execution of all the arrangements for firing, and particularly the security of all joints, should be examined carefully. These joints serve to connect the metallic parts of the lines and are likely to cause trouble whenever used in primings and lead wires.

"Such difficulties can be overcome by the employment of competent men for the direction, superintendence and execution of the work."

USE OF MELINITE.

SUPPLY.

Infantry and Cavalry.—Since infantry and cavalry are obliged at times to remove certain obstacles without resorting to tools, whose use requires a considerable time and offers great difficulties under the fire of the enemy, they are provided in the field with a supply of explosives in whose use the pioneers of these two arms are trained in time of peace. Indeed, each corps has allotted to it a fixed quantity of melinite petards, detonators and money with which these pioneers execute a number of demolitions.

Melinite has the same destructive power, weight for weight, as dynamite but, being of greater density, it produces greater effect for equal volumes. Moreover, melinite is devoid of the greater part of the disadvantages of dynamite. It does not freeze and is detonated by shock only when the latter is very violent; it is very rarely exploded by the impact of rifle balls and when this does occur, the detonation does not spread. This insensibility to shock greatly facilitates the use of melinite in actual work. Melinite petards can be bent by striking them with a hammer and can thus be made to conform to the shape of the surface to which they are to be applied. They can also be nailed to the pieces of timber that are to be destroyed.

The *field supply* of melinite for infantry (108 petards [32.4 lbs.] and 48 detonators to a regiment) is insignificant in amount.

The replenishment of the supply of explosives for infantry is provided by the artillery service from its reserve supply, distributed between the ammunition column and the artillery park of the army corps.

In the *cavalry*, every man carries a melinite petard in the pocket provided for it in the saddle bag. The boxes of detonators are distributed among the sergeants, corporals and pioneers. There are two Bickford safety fuzes per box. The supply of melinite provided for cavalry regiments, active and reserve, is therefore as follows:—

Corps Cavalry Regiments.

Squadrons with the colors	600 petards,	200 detonators.
Squadrons in the reserves	600 petards,	200 detonators.
Depot	300 petards,	100 detonators.
Total	1,500 petards,	500 detonators.

Independent Cavalry Regiments.

Squadrons with the colors	600 petards,	200 detonators.
6th squadron, if there be one	150 petards,	50 detonators.
Depot	300 petards,	100 detonators.
Total	1,050 petards,	350 detonators.

[One petard contains .3 lbs. of melinite.—Translator.]

Moreover, with each independent division of cavalry there is an ammunition wagon that carries 800 detonators, 720 fulminate fuzes, 720 Ruggieri igniters, 10 cases of melinite petards containing 1480 petards of 135 grams each, or 200 kilograms [440 lbs.] of melinite, and 800 meters of Bickford safety fuze.

It is therefore evident that in the infantry and cavalry it is necessary to be economical in the use of melinite since the total supply available for them may be expended in a single demolition of any considerable importance. It is also evidently necessary to reserve it for use under pressing conditions and particularly for the destruction of iron or steel.

Engineers.—Engineer companies are each supplied with 70 kilograms [154 lbs.] of melinite in four ammunition packs. Each company of railroad pioneers has an ammunition wagon with 380 kilograms [836 lbs.]. The engineer train of an army corps has a similar ammunition wagon and there are three of them in the general army train. These supplies are sufficient for the execution of large demolitions since it is rarely necessary to use heavy charges.

MELINITE PETARDS.

The *melinite petard, model of 1886*, consists of a brass case of prismatic form and about .15, .03 and .02 meters [4.9, 1.2 and .8 inches] on the three sides, in round numbers. It contains 135 grams [.3 lbs.] of melinite. The larger part of this is fuzed melinite but the portion around the detonator chamber is granular melinite which alone can be detonated by the service detonator.

To the lid or cap is soldered a small tube, called the *detonator chamber* (Fig. 18, Plate VI), that projects into the interior of the case and is designed to receive the detonator to explode the petard. Its orifice is closed by a strip of wire that is removed at the time the detonator is inserted. The lid or cap is covered by a guard of pewter.

The melinite petard of 135 grams has the same dimensions as the old petard containing 100 grams of dynamite.

MELINITE CARTRIDGES.

The *cartridge, model of 1895*, containing about 100 grams [.22 lb.] of melinite, is used only in the engineer service. Its general arrangement is the same as that of the petard excepting that it is cylindrical in form and that it is .13 meters [5.12 inches] long by .03 meters [1.2 inches] in diameter.

Since the cases containing melinite are waterproof it is not necessary to take the same precautions against moisture as in the case of charges of gunpowder.

Resort may also be had to petards containing 1 kilogram [2.2 lbs.] which are to be found in the supplies of fortified places. They are contained in cases made of brass or of waterproof paper.

DETONATION OF A PETARD.

To summarize, in order to detonate a petard with the slow fuze it is necessary:—

1. To prime the petard, that is, to place the detonator as described above.
2. To prime the detonator by thrusting into the latter one end, cut square and well cleaned, of the slow fuze as has also been described above.
3. If a Ruggieri igniter is available, place it upon the other end of the fuze, which should also be cut square.

To simplify the work, the detonators provided with the field supplies are prepared with their fuzes and igniters. The igniter may be lighted, as in the case of the Bickford fuze, by a piece of tinder, a smoker's fuzee or even by an ordinary match. The lighting should be entrusted to a cool-headed man who will do it deliberately, at the given signal, and will observe all of the precautions prescribed for assuring its efficacy. He should retire to a distance as soon as he hears the hissing that occurs when the Bickford fuze begins to burn, placing the free end of the fuze on the ground carefully in order not to disarrange the priming.

To make a double ignition, take in the left hand the igniters of the two detonators and light them. By holding in the left hand the igniters of several detonators, a number of charges may be fired at the same time.

In order to avoid all possibility of accidents, it is necessary to withdraw to a distance of at least 150 meters from the object to be destroyed. It has been stated above that a length of 1 meter of Bickford fuze will allow a man to retire to that distance at an accelerated pace.

When the charge consists of a single petard, care should be taken to apply the largest face (.15 meters by .03 meters) of the petard as closely as possible in contact with object to be destroyed.

Practically simultaneous explosions of several charges may be obtained by making the Bickford fuzes of equal lengths. This is called the equalization of fuzes, as stated previously.

But, to obtain that absolute simultaneousness which is often indispensable when several charges are intended to unite in the production of a common result, or to avoid the use of excessive lengths of Bickford fuze, resort must be had to the detonating fuze that is supplied only to the engineers.

It is not intended to go into the details of the use of explosives by engineer troops since that arm receives full instruction on the subject. It does, however, appear obligatory to enter into all of the developments of the subject that are of interest to the infantry and cavalry.

USE OF VARIOUS EXPLOSIVES.

Dynamite and Gun Cotton.—Infantry and other arms may make use of various explosives (dynamite and gun cotton) in exceptional cases and when melinite petards are not available. The charge to be used in each particular case is determined by assuming that these explosives may be substituted for melinite, weight for weight.

All of the instructions given for melinite in connection with priming, the preparation and placing of charges, their ignition and the precautions necessary to avoid accidents, are applicable to these explosives.

Gunpowder.—The use of gunpowder in demolitions is the exclusive function of engineer troops. The general information already given in connection with this subject makes it evident, indeed, that the management of this explosive and its preparation for action under varying conditions, require instruction and experience that can not be made available to all arms.

CHAPTER V.

EXECUTION OF DEMOLITIONS WITH EXPLOSIVES.

MEANS TO BE EMPLOYED IN PARTICULAR INSTANCES.

The following instructions relate to the application of the preceeding general rules to particular cases and are intended to permit the complete solution of the question as to the most practical and exact method to be followed in any particular instance.

Circumstances may, however, be such as to require that demolitions be made under the fire of the enemy or when all the means necessary for the work are not available. In such cases, substitutes must be used for the supplies that are wanting and the simplest and quickest methods must be employed in placing charges. Thus, when the charges must be suspended, arrangements should be made in advance for hanging them up by means of heavy wire hooks, or for sustaining them on supports to which they have been previously secured or for attaching them by means of lashings.

In such cases it is nearly always desirable to ignite each charge seperately in order to avoid the disadvantages resulting from misfires and from the exposure when the operation lasts to long.

Improvised methods vary with the conditions of the case and require considerable experience that can only be acquired by study and practice.

LOOPHOLES.

A charge of four petards, suspended against a wall of average thickness will make an excellent loophole when detonated. In making a breach or loophole it is necessary to withdraw, after lighting the fuse, to a distance of only 50 meters along the face of the wall in order to be out of danger from the explosion.

This method is expeditious but when any considerable number of loopholes is to be made it requires too large a quantity of melinite.

WALLS AND ARCHES.

The charges to be used to make a breach in or to throw down a wall will depend upon whether the wall is banked with earth or not and upon whether the charges are concentrated or elongated, with or without tamping, placed in holes or not, and finally upon the depth of the holes containing the charges.

In general, in order to economize explosives, elongated charges should be placed in holes prepared for them when the wall is more than .6 meters [24 inches] thick. Emplacements for concentrated charges may be made by one or more small charges that loosen the masonry, the operation being repeated until the desired depth is obtained.

With walls nearly .8 meters [31.5 inches] thick it is preferable to use only elongated charges and when the wall is thicker than .8 meters it is better to use only gunpowder.

The character of the charges and the methods to be employed will also depend upon the amount of melinite and of time available, the size of the walls, the length of breach desired, etc.

ISOLATED WALLS.

The walls under consideration are the walls of inclosures and houses, bridge piers, etc.

In all cases, in order to obtain a breach to the full height of an ordinary wall, it is necessary for the length of the breach, and consequently the length of the charge, to be at least equal to one and a half times the height of the wall.

Elongated charges are used for inclosure walls from .3 to .6 meters [12 to 24 inches] thick and the weight of melinite per linear meter is calculated by one of the three following formulas, in which C is the weight in kilograms [pounds] and e is the thickness of the wall in meters [feet]:—

(1.) When the charge is merely placed at the foot of the wall: —$C=10e^2$ [$C=2e^2$].

(2.) When the charge is placed in holes in the wall:—$C=5e^2$ [$C=1e^2$].

(3.) When the charge is placed in holes in the wall and tamped: —$C=3e^2$ [$c=.6e^2$].

That is, for a wall .5 meters [1.64 feet] thick, a charge of 2.5 kilograms (18 petards) [5.5 lbs.] in the first case, of 1.25 kilograms (9 petards) [2.75 lbs.], in the second case, and of .75 kilograms (6 petards) [1.65 lbs.] in the third case, per linear meter of the breach to be made.*

With walls of the above mentioned thickness (.5 to .6 meters) [20 to 24 inches] in actual practice a trench is dug at the foot of the wall and in it are placed three rows of petards or about 20 petards (2.7 kilograms) per linear meter [5.5 lbs. per yard] of breach. This charge is lashed to a rod of wood or to a cord whose length is equal to the breach to be made. The petards are covered with a tamping of earth from the trench. This charge is amply sufficient in all cases.

It is also possible, especially when pressed for time, to dispense with the placing of the charge in holes when demolishing walls, without exceeding 4 kilograms [8.8 lbs.] per linear meter.

The charge should always be placed in holes when the wall is from .6 to .8 meters [24 to 31.5 inches] thick and when this thickness exceeds .8 meters, the charge should be placed in holes and tamped in order to avoid the use of excessive charges. The preparation of the hole for the charge may be shortened by starting at the foot of the wall with a row of petards placed end to end. The holes thus made are shaped out with a pick.

With walls thicker than .8 meters [31.5 inches] it is better to use concentrated charges calculated from the formula, $C = Ae^3$, in which the coefficient A is equal to 50 for charges merely placed at the foot of the wall, 11.5 for charges buried in the foundations 5 for charges buried in the wall to their own depth and 2 for charges buried in the wall to ⅓ the thickness of the latter and lightly tamped.†

The lengths of the breaches produced by these charges are respectively $2.3 \times e$, $2.2 \times e$, $2 \times e$ and $1.30 \times e$, corresponding to the coefficients 50, 11, 5.5 and 2.‡

The spacing of the charges should be equal to the lengths just given and such a number of charges should be used as will make the length of the breach at least one-and-a-half times the height of the

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[*The words in brackets give a transposition of these formulas and results into feet and pounds.—Translator.]

[†When C and *e* are in pounds and feet the above values of A become 3.13, .72, .31, and .125, respectively.—Translator.]

[‡7.5×e, 7.25×e, 6.5×e, and 4.25×e, corresponding to the coefficients 3.13, .72, .31, and .125, when *e* is the thickness of the wall in *feet*.—Translator.]

wall. As in the case of elongated charges, it is absolutely necessary to bury the charge when the wall is .8 meters [31.5 inches] or thicker. The diffierent charges are connected together with the detonating fuse and one of them near the center of the desired breach, is primed.

This method of demolishing walls thicker than .8 meters, [31.5 inches] requires large quantities of melinite and should be reserved for use only in cases where rapidity of action is required as, for instance, under fire of the enemy.*

In all other cases it is better to use gunpowder. The powder should be placed at the foot of the wall in charges of 15 kilograms [33 lbs.], spaced at intervals of 1 meter [30 lb. charges at 1 yard intervals] and tamped, as shown in Fig. 19, Plate VII, by piling upon them such earth, stone and other general debris as may be available.

In the demolition of *isolated walls whose thickness is 2 meters [6 feet] or more* good results can be obtained with gunpowder only when the arrangement permits of its being well tamped. It is much more economical to use than melinite.

The engineer service alone has means of sufficient power for all such cases since walls of this thickness can be demolished only by preparing in the interior of the masonry a system of mines that are so arranged as to make their craters intersect or at least become tangent to each other. The charges for these mines should be increased $\frac{1}{10}$ on account of the unusual resisting power of the material.

The mine chambers are reached by tunnels. The arrangement shown in Fig. 20, Plate VII, has a tunnel for each mine chamber and can be prepared most rapidly but, as it can not be fully tamped, it requires an increased charge. With the arrangement shown in Fig. 21, Plate VII, it is usually possible to tamp fully and the normal charge will suffice. In these two cases the tunnels should have the smallest possible section and the tamping should be done with the greatest care. The preparation of the chambers may be expedited by the use of successive small charges of melinite.

With walls from *1 to 3 meters [3 to 10 feet] thick*, the mines may be placed under the foundations. To accomplish this, a pit is dug at one face of the wall (Fig. 22, Plate VII), and a chamber made under the foundations if they are not deeper than 2 meters [6 feet], or the charge is placed in the foundations themselves.

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*Thus, for a wall .8 meters [31.5 inches] thick and the charge buried in the foundations, the formula $C = Ae^3$ becomes $C = 11.5 \times .8 \times .8 \times .8 = 5.888$ kilograms [13 lbs.], with a resulting breach of $2.2 \times .8 = 1.76$ meters. For a wall 2.3 meters [7.5 feet] high, a breach 3.45 meters [11.3 ft.] long will be required, or two concentrated charges containing 12 kilograms [26.5 lbs.] of dynamite, in round numbers.

RETAINING WALLS.

When it is desired to simply throw down a retaining wall, it is only necessary to appply concentrated charges of gunpowder or melinite at the back of the wall, either placed merely in contact with it or located in chambers within the wall. In such cases it is more economical to use gunpowder since large charges are required and the tamping can be well provided for. Plenty of timê will be available when works are to be destroyed.

In other respects the arrangements would be the same for melinite as for gunpowder but the charge would be reduced one-half.

Operations of this character are carried out only for the purpose of making a breach or of dismantling a fortified place and can be executed only by the engineers. The subject will be considered only to the extent of indicating concisely the method of proceedure when gunpowder is used.

The charges are calculated by the formula $C=gh^3$, in which h represents the distance from the center of the charge to the face of the wall and g is approximately equal to 3.* The intervals between charges should not be greater than twice the thickness of the wall at the point where rupture is desired.

The charges are placed in different ways according to circumstances. Use may be made of pits or drilled holes sunk from the earth surface at the top of the wall or a pit may be made at the foot of the wall to the bottom of the foundation, under which the mine is placed (Fig. 23, Plate VII).

Mines may also be prepared in the wall itself, a short distance above its base, or with the aid of a boring or drilling machine and by successive small charges of melinite, an opening may be made through the wall and a chamber prepared in rear of it by exploding small preliminary charges. When chambers are made by the use of pits or tunnels, it is desirable to locate the charge within the wall itself, wholly or in part. In all cases the mines should invariably be located at the salients of the works to be destroyed.

The opening of a breach in a revetted parapet, to prepare a passage for an assaulting column, will be only briefly mentioned. The work is very difficult and dangerous and is but little used in actual service

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*If C and h are in pounds and feet, g is approximately equal to .2.—Translator.

Plate VII.

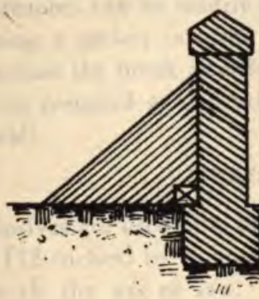

Fig. 19.

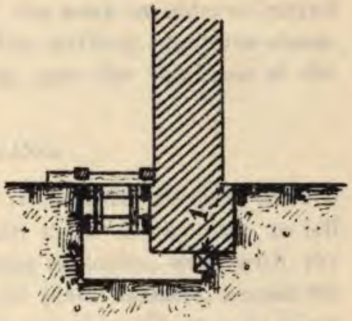

Fig. 22.

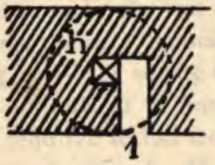

Fig. 20.

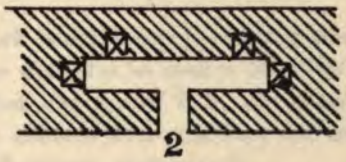

Fig. 21.

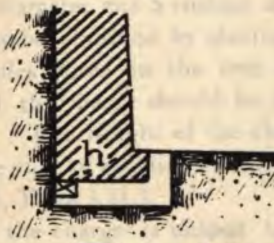

Fig. 23.

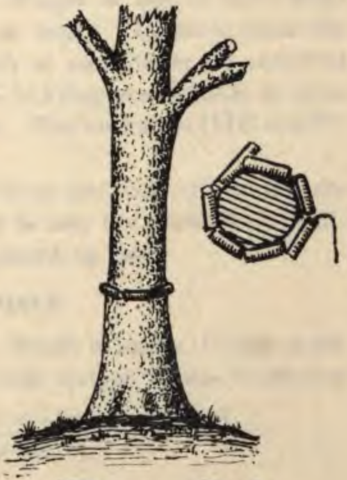

Fig. 24.

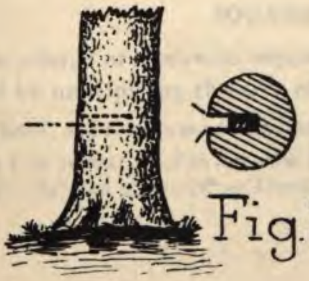

Fig. 25

since breaches can be readily made with artillery. It is accomplished by mining a gallery into the parapet of the work in order to extend and increase the break already made by the artillery, the mine chamber being prepared at a depth dependent upon the thickness of the scarp wall.

TREES AND PILING.

Explosives are used only on pieces of timber that are more than .3 meters [12 inches] in diameter and when there is not time to fell them with the axe or saw. When using explosive, work with the axe may be limited to the preparation of plane surfaces around the circumference of the tree to receive the petards. The tree or piece of wood is encircled by a necklace or girdle of petards (Fig. 24, Plate VII), held in place by lashings of twine. The charge is so arranged that there will be a larger amount on the side towards which it is desired to make the tree fall.

The charge required for such work is determined, in kilograms, by multiplying by 10 the square of the diameter in meters ($C=10d^2$).* From this formula it is found that charges of 7, 9, 12, 16 and 20 petards are required to fall trees or timbers with the bark on, whose diameters are .3, .35, .4, .45 and .5 meters, respectively.

When time permits and the necessary tools are available, economy in the use of explosives (3 petards instead of 10 for a tree .3 meters [sic] in diameter and 5 instead of 20 for one .4 meters [sic] in diameter) may be obtained by placing the charges in one or more small radial holes bored in the tree with an auger. In such cases the center of the charge should be as nearly as possible at the center of the tree. The weight of the charge C in kilograms is equal to three times the cube of the diameter in meters. The formula is [1] $C=3d^3$†. (Fig. 25, Plate VII.)

When the charge is heaped in a pile on one side of the tree the formula becomes [2] $C=30d^3$†; that is to say, the quantity of melinite required is ten times that in the preceding case.

SQUARED TIMBER.

The charge of melinite required to break a square timber is obtained by multiplying the area of its cross section by the coefficient

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[*When C and d are in pounds and feet the formula becomes $C=2d^2$.]

†For C in pounds and d in feet these formulas become:—
[1] $C=.2d^3$ and [2] $C=2d^3$.—Translator.

10 for soft wood or 13 for hard wood. That is [3] $C=10ab$ or $13ab$.[*] If the charge is placed in auger holes in the timber the formula to be used is [1] $C=3d^3$[*] as in the preceding case.

WROUGHT AND CAST IRON AND STEEL.

To break pieces of wrought iron, steel or cast iron, use is made of the formula, [4] $C=3000ab^3$,[†] in which C is the weight of the charge in kilograms, a is the width and b the thickness in meters of the piece to be broken. If the pieces are cylindrical or prismatic the formula becomes [5] $C=3000d^3$,[†] d being the diameter of the cylinder or of the circle circumscribed about the prism.

These formulas are applicable to all ordinary dimensions with the exception that when the width a of the piece is less than .1 meters [3.94 inches] the assumption must be made that $a=.1$ meters [3.94 inches] in the formula $C=3000ab^3$.

The charge must always be placed in close contact with the piece to be broken and should be tamped, if only lightly.

PALISADES AND FRAISES.

To destroy palisades constructed of posts joined together and from .1 to .2 meters [4 to 8 inches] thick, it is necessary to place at their lower ends, in close contact with them, an elongated charge of 2 kilograms [4.4 lbs.] per linear meter, [4 lbs. per linear yard] formed of two rows of petards placed end to end.

If the posts are .2 to .3 meters [8 to 12 inches] thick, the charge is increased to 2.8 kilograms [6.2 lbs.] per linear meter, [5⅔ lbs. per linear yard] and the petards are arranged in three rows.

When gunpowder is used, the weight of the charge is increased in order to lessen the amount of tamping. Bags containing 10 kilograms [22 lbs.] are placed at intervals of a meter and packed closely against the posts. An effort should be made to rapidly tamp the charge with a number of sand bags.

Fraises are destroyed in the same manner as palisades, the charges being placed underneath the portion that is to be demolished.

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[*] For C in pounds and d in feet these formulas become:—

[1] $C=2d^3$, and [3] $C=2ab$ or $2.5ab$.

[†] For C in pounds and a, b and d in *feet*, these formulas become [4] $C=56.5ab^3$ and [5] $C=187.5d^3$.

For C in pounds and a, b and d in *inches* they become, $C=.032ab^3$ and $C=.11d^3$.

There is evidently an error in one or the other of these formulas, probably in [4] which, for approximate correspondence with [5], should read, $C=3000(\sqrt{ab})^3=3000\overline{ab}^{\frac{3}{2}}$ with equal coefficients in the two formulas as written for English units of weight and measure.—Translator.

STOCKADES.

Stockades of round timbers require charges of 30 kilograms [66 lbs.] of gunpowder per linear meter, with a light tamping. Six kilograms [13.2 lbs.] of melinite, arranged as an elongated charge, will produce the same result without tamping.

In short, the methods are the same as for palisades but double charges are required.

IRON GRATINGS OR FENCES.

To make a breach it is generally sufficient to place against the grating or fence an elongated charge of melinite of 2 to 3 kilograms [4.4 to 6.6 lbs.] per linear meter.

GATES OR BARRIERS.

Two petards [.6 lbs.] applied to each of the points where the gate is attached to the masonry will usually be sufficient to break it down. In the case of a locked gate, one or two petards [.3 to .6 lbs.] should be detonated against the lock. In the absence of high explosives, a charge of 15 kilograms [33 lbs.] of gunpowder should be placed against the lock.

Two petards [.6 lbs.] applied to each of the hinges of a wooden gate closing a carriage way will break down the gate. If it is merely locked the method to be followed is the same as for the locked gate above.

If the gate is barricaded, a charge of two petards [.6 lb.] should be applied to each of the hinges and to the lock. The simultaneous explosion of these charges will overthrow the gate.

An elongated charge composed of two rows of petards, may also be placed across the gate in order to avoid the difficult task of producing too large a number of simultaneous explosions. If the gate of a carriage-way is very substantial it may be necessary to place at the bottom of it a sack containing 20 petards, 2.7 kilograms [6 lbs.].

When melinite is not available, a sack containing 15 or 20 kilograms [33 to 44 lbs.] of gunpowder may be suspended against the center of the barrier at the level of the locking system.

ABATIS.

To break up an abatis, a charge of 25 kilograms [55 lbs.] of gunpowder is placed under the trunk of one of the trees without tamping. The same result may be obtained with a melinite charge of from 4 to

IMPROVISED OBSTACLES.

It is difficult to state the size of the charges of gunpowder or melinite that would be required to destroy improvised obstacles such as harrows, ploughs, spiked planks, wagons, rails, etc., heaped together to form a barricade. The method to be followed should be that indicated for conditions that most nearly approximate the case in hand.

VEHICLES.

A vehicle of any kind may be disabled by detonating a concentrated charge of four petards [1.2 lbs.] applied to one of the axles.

ICE.

Either of the two following methods may be used to break up ice:—

1. When ice is from .1 to .3 meters [4 to 12 inches] thick, place upon the surface a charge of one, two or three petards, [.3 to .9 lb.] depending upon the thickness, prime one of them and fire the charge.
2. Make a small hole in the ice and introduce a petard [.3 lb.] which should be inserted as far as the ice is solid and should be completely submerged in the water, taking care, however, to keep above the water the joint between the detonator and the fuze.

In such work it is useless to fire several charges at the same time. It is better to use petards one at a time and the best results are obtained by gradually extending operations, each explosion producing results in the immediate vicinity of the parts previously attacked and following the line of rupture determined upon.

An elongated charge of melinite petards placed end to end on the ice and tamped with sand or blocks of ice will break up a layer of ice as thick as .5 meters [20 inches].

HIGHWAYS.

Travel over a highway may be interrupted for an appreciable time only by the destruction of bridges, whose demolition will be referred to hereafter. Indeed the damage done by blowing up the roadway with mines can generally be readily repaired and travel resumed by a few hours' work of a temporary character. The interruption may, however, be serious if the road is destroyed on the side of a hill, in a deep cut, over marshy ground and, especially, at the crossings of water courses.

When the road is on a side hill, mines should be placed towards the down-hill side. The charges for these mines is found from the formula, $C = gh^2$ (Fig. 26, Plate VIII) in which C is the weight of

Plate VIII

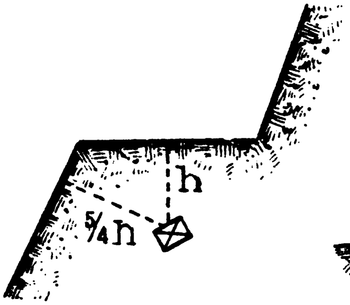

Fig. 26.

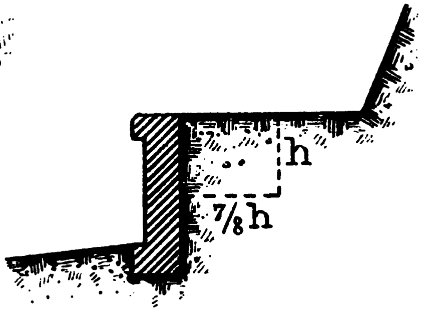

Fig. 27.

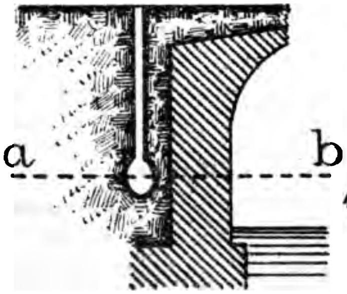

Fig. 29.

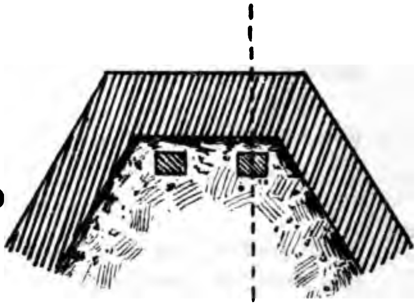

Fig. 30.

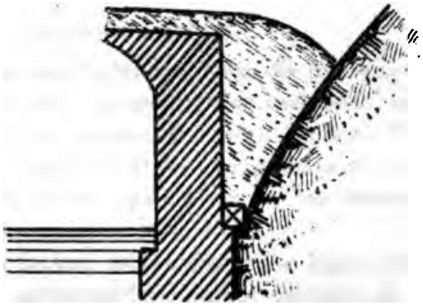

Fig. 31.

charges that are calculated by one of the three formulas that have been given for felling trees. In order to make repairs more difficult, the supports should always be broken off below the surface of the water, the fuze of the petard being invariably placed above water.

Masonry culverts are destroyed by placing on the crown of the arch a concentrated charge of 1, 6 or 15 kilograms [2.2, 13.2 or 33 lbs.] of melinite according as the thickness of the arch is .3, .6 or .9 meters [12, 24 or 36 inches.] These charges should be covered or tamped with sand or earth and may be reduced one-half if placed in holes in the masonry.

To destroy a *metal bridge* of small span and in which the T-irons do not exceed .3 meters [12 inches] in height, there should be placed on the outside of each beam and near the points of supports a charge of five petards, arranged obliquely and extending the full height of the beam. The charge should be firmly secured with wire, battens and wedges.

Suspension bridges may be destroyed by cutting the metal suspension cables at one end with petards.

BRIDGES AND VIADUCTS.

The destruction of bridges and viaducts produces a serious interruption of lines of communication and is consequently the most efficacious means of impeding the enemy's movements.

The roadway or the arches of a bridge are destroyed only when pressed for time since such parts are easiest to repair. The piers or supports should preferably be selected, with greater resulting injury. The piers are less difficult to demolish than the abutments (the supports of the bridge upon the two banks.)

TIMBER BRIDGES.

When the bridges are very light, and have the roadway only 1 or 2 meters above the water, as is generally the case with bridges built during campaigns, a charge of from 10 to 20 kilograms [22 to 44 lbs.] of melinite or of 50 kilograms [110 lbs.] of gunpowder submerged to a depth of 2 meters and placed against one of the trestles will generally be sufficient to throw down several bays.

The supports may be broken either above the water with melinite or below the surface by submerged charges of melinite or gunpowder. It is better to place the charges below the surface of the water (at least .5 meters) in order to avoid the necessity of tamping and to make repairs more difficult.

If the bridges are built upon piling, the powder charges should be placed between the piles at a depth of 2 to 3 meters. When so placed a charge of 50 kilograms [110 lbs.] of gunpowder will destroy a bent composed of three piles .24 meters [9.5 inches] in diameter and spaced 1.4 meters [4.6 feet] apart.

When melinite is used the charge for each pile or support is determined separately, as in the case of trees and sticks of timber, from the formula $C=10ab$ in which C is the charge in kilograms and a and b are the breadth and width in centimeters.*

To obtain simultaneous explosions electric fuzes and exploders should be used or the various charges should be connected together by the detonating fuze.

The roadway may also be destroyed by placing 100 kilograms [220 lbs.] of gunpowder over the center of each of the beams that supports it, tamping the charge with earth or ballast. Such a charge will break down a bridge of any span.

The floor-beams may also be broken with melinite, using the formula, $C=10ab$, given above. The charge should extend the full height of the beam and must all be detonated simultaneously.

If the bridge is built on rafts a charge of 25 or 30 kilograms [55 to 65 lbs.] of gunpowder, or half that amount of melinite, placed on the roadway over one of the rafts will be sufficient to destroy two bays.

If the supports are of masonry, but of small thickness, they may be destroyed in the manner described for the demolition of isolated walls. If the masonry is heavy resort must be had to the methods given below for masonry bridges.

MASONRY BRIDGES.

PERMANENT ARRANGEMENTS.

Preparations are usually made in advance for the demolition of masonry bridges. In such cases the mines are established in the piers for the reason that the destruction thereby obtained is much more complete. At the same time they should be placed as low as possible in order to increase the difficulty of making repairs.

The permanent systems include powder chambers and shafts or galleries giving access to them (Fig. 28, Plate IX). Each chamber has its corresponding shaft or gallery but sometimes two chambers are

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*This is evidently an error and should read *meters* (see page 45). The corresponding formula for C in *pounds* and a and b in *feet* is $C=2ab$ or $C=.014ab$, when a and b are expressed in *inches*.—Translator.

Plate IX.

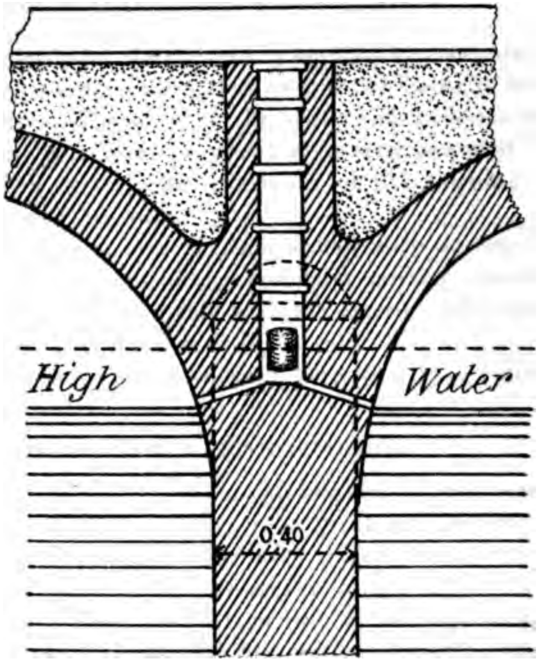

Fig. 28.

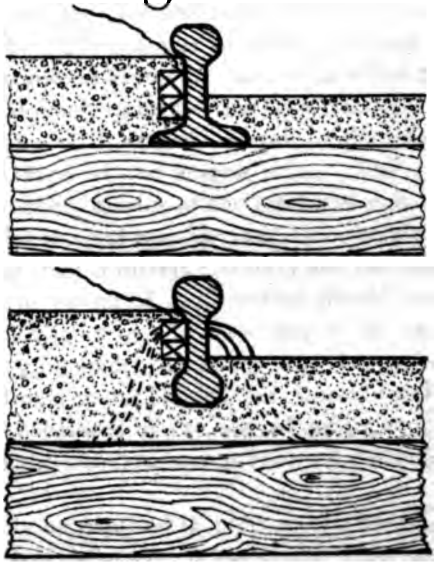

Fig. 32.

reached by the same shaft. In the latter case the chambers are placed at the two extremities of a gallery that extends horizontally from the bottom of the shaft. The walls of the shafts and galleries are provided with grooves or recesses to receive transverse pieces of timber that are intended to increase the resistance of the tamping. The latter can not be made too solid.

Access is had to these systems through a shaft with an entrance on one side of the roadway. In foreign countries powder chambers are sometimes found that communicate with the exterior only through a straight passage that does not permit of tamping.

The size of charges is not considered here since it is posted near each mine chamber.

IMPROVISED ARRANGEMENTS.

General Remarks.—If no preliminary arrangements have been made the demolition of a bridge will require a great deal of time unless access can be had to open spaces that have evidently been left in the spandrels. It will otherwise be necessary to attack either the piers, abutment or arches. Their destruction may be accomplished by the use of gunpowder or high explosives but preferably by the latter.

DESTRUCTION OF PIERS.

Piers may be destroyed with gunpowder by using ordinary mines placed on the center line of the pier and as far as possible below the springing line of the arch. The number of mine chambers is determined by fixing upon a common radius of rupture for all of them and by placing their centers at such intervals that the circles of rupture described about these points will intersect outside of the pier, or will intersect at least in the faces of the longest sides. The corners of the pier should fall within the interior of the circles of rupture of the outside mines. A simpler method may be used and the pier may be divided into lengths of at least 3 meters [10 feet] and not more than 6 meters [20 feet]. At the center of each section should be placed a mine whose charge is calculated in the same way as for an isolated wall. The amount of gunpowder necessary may be estimated at about 25 kilograms per linear meter [17 lbs. per linear foot] of pier. The mine chambers are excavated by the use of galleries which are located and excavated in the same manner as has been described above for isolated walls.

Less time will generally be required if piers are destroyed by melinite petards. In such cases a platform is suspended from the pier or built upon boats. The use of melinite dispenses with the necessity of placing the charges at the center of the pier and permits of good results with very light tamping.

When the pier has a thickness less than 1.5 meters [5 feet], it is better to place an elongated charge horizontally along one face and as low down as possible. The formula used in this case and when the charge is merely placed in contact with the piers is,* [1] $C=10E^2$, in which C is the charge in kilograms of melinite per linear meter and E is the thickness over all of the pier. If the charge is placed in a groove having a depth of .15 meters [6 inches], the proper formula is,* [2] $C=5E^2$.

For piers having a thickness greater than 1.5 meters [5 feet] it is necessary to employ concentrated charges located entirely within the masonry and tamped. The charges for such mines are calculated from the formula,* [3] $C=5h^3$, in which *h* is the distance of the charge from the most distant face of the pier, the distance between any two mines being 2*h*. Simultaneous explosions are obtained by using the detonating fuse.

DESTRUCTION OF ABUTMENTS.

The most expeditious method of destroying bridge abutments is to establish mine chambers by using a miner's drill, the chambers being located about .4 meters [16 inches] from the interior face of the abutment, for the reason that the formation of these chambers is somewhat difficult in direct contact with the masonry (Fig. 29, Plate VIII).

The powder charge is calculated from the formula,* [4] $C=30E^3$, in which E is the thickness of the masonry. Ordinarily two mines are employed, one being placed in each of the angles formed by the face and the two wings of the abutment (Fig. 30, Plate VIII).

When sufficient time is available the mine chambers are placed against the interior face of the abutment as low down as possible and tamped with earth or, if possible, buried in the masonry itself. In such cases the rules laid down above for retaining walls should be followed.

When gunpowder is not available elongated charges of melinite should be placed at the bottom of a trench, excavated behind the abutment wall and carried along its entire length. The earth excavated from the trench will serve for tamping (Fig. 31, Plate VIII). In such cases the charge per linear meter is calculated from the formula,* [5] $C=1.25E^3$. The method and the formula given above for piers less than 1.5 meters thick may also be employed.

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*For C in pounds and E in feet these formulas become [1] C = [illegible]E, [2] C = .3E, [3] C = .3h³, [4] C = 1.2E³ and [5] C = .022E³.—Translator.

DESTRUCTION OF ARCHES.

To destroy the arches of a bridge a trench at least .5 meters deep should be excavated above the center of the arch and charged with 150 to 200 kilograms [330 to 440 pounds] of gunpowder, that should be tamped with earth, stone, ballast, rails, etc. The charge should be increased near the parapets, where the resistance of the masonry is the greatest.

The charge of gunpowder may be replaced by an elongated charge of 7 kilograms of melinite per linear meter [4.5 pounds per linear foot]. It is advisable to make at intervals of 2 meters small trenches, perpendicular to the main trench and about 1.5 meters long, charging these transverse trenches also with melinite. The formula,* [3] $C=5h^3$, may also be used.

When time is pressing, an arch of a bridge may be destroyed by placing under the intrados a charge of 300 or 400 kilograms [660 to 880 pounds] of gunpowder, supported in any practical manner in contact with the arch. A charge of 50 kilograms [110 pounds] of melinite will produce an equal result.

An arch may be broken down at the haunches or at the center by high explosives without tamping. In such cases the formula, †[6] $C=50h^3$, is applicable to concentrated charges and the formula, †[7] $C=10h^3$, gives the amount per linear meter for elongated charges.

The powder may also be simply placed in a pile upon the pavement of the bridge above the center of the arch. Three piles of 100 kilograms [220 pounds] each will destroy an arch having a thickness of 2 meters at the center. The charges should be covered with balks, planks, sandbags, etc., so as to form a light tamping. The three separate piles must be exploded simultaneously.

When but a small amount of gunpowder is available, two trenches should be excavated at the haunches of the arch and carried down to the extrados. At the bottom of one of these trenches two or three mines, each containing 12 to 15 kilograms [26 to 33 pounds] of powder, should be placed and tamped with any available material.

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*See foot-note on page 54.

†For C in pounds and E in feet these formulas become [6] $C=3h^3$ and [7] $C=.18h^3$. —Translator.

IRON AND STEEL BRIDGES.

TRUSS BRIDGES.

The use of gunpowder requires very large charges and a heavy tamping that is difficult to realize in campaign. For these reasons high explosives are exclusively used for the demolition of iron and steel bridges. In destroying such bridges the trusses are generally selected as the point of attack. It is necessary to break all of the longitudinal pieces in one cross-section of the truss but the web members may be neglected. In practice it is customary to make the break obliguely, in the form of a scarf, in order to facilitate the fall of the girders after the explosion. Points should be selected where the metal is thinnest and where the ends of the fallen truss will not be serviceable as supports for subsequent repairs. The selection of the cross-section is based upon these principles.

The cross-section of rupture should be located 1 or 2 meters from the points of support (abutments or piers), for the reason that at the ends of the bridge the metal is generally thinner and the charges can be more readily placed.

In any cross-section of rupture the charge should be varied from point to point according to the character of the metal, its thickness and as to whether the plates have a full section or are riveted. As a general rule, the number of petards in each element of a charge designed to break a plate of steel or iron will be equal to the thickness of the plate in centimeters. The following table gives a general idea of the number of petards required:—

Thickness over rivets,		1 c.m.	2 c.m.	3 c.m.	4 c.m.	5 c.m.
No. of rows of petards,	iron,	1	3	5	8	14
	steel,	1	4	6	10	16

Charges should be placed as closely as possible in contact with the metal. The heads of rivets should be blown off, since it will otherwise be necessary to add the thickness of these rivet heads to that of the metal. Moreover, all charges should be as well covered as possible with planks to form a tamping.

The general formula for breaking pieces of metal is, $C = .0003ab^2$, in which a is the smaller dimension, in meters, of a rectangular cross-section of the piece, and b is the larger. The length of the charge should be equal to b^2 (sic).

To obtain the complete rupture of a beam all the elements of the charge should be detonated simultaneously and should therefore be connected by rows of petards or by a detonating fuze. If explosives are not available the piers or abutments may be destroyed, but in such cases the trusses remain intact and repairs may be easily made.

SUSPENSION BRIDGES.

The towers supporting the cables of a suspension bridge may be blown down with petards, following the methods described above for the destruction of masonry bridges. The cables or chains may be also cut with melinite, and the size of the charge may be determined from the formula, $C=3d^3$, in which C is the charge in grams and d is the diameter of the cable in centimeters.

RAILROADS.

Since railroads are employed almost exclusively for strategic communications alone there is little gained in field operations by causing interruptions of traffic of only short duration. Nevertheless, the destruction of the roadbed proper by explosives may prove to be of great service in many cases. These damages may include the blowing up of a bridge, the destruction of considerable length of the roadbed or of special points, such as junctions and crossings.

RAILS.

Two petards will be sufficient to break a rail of either iron or steel and of any shape.

These breaks may be made either single or double, depending upon the amount of time available and the orders received relating to the work. In making a *single break* the location of the charge should be first prepared by uncovering the rail in the space between two consecutive cross ties. Two petards should be then placed lengthwise, one upon the other, and applied closely to the web of the rail immediately above the base (Fig. 32, Plate IX). They should be firmly secured in this position by a lashing around the rail, by ballast or by any other means, particularly in the case of double-headed rails. One of the petards should be primed with a slow fuze and the tamping completed by covering the charge and a part of the Bickford fuze with earth. After having ignited the fuze the party should withdraw about 100 meters up the track. The break will be about .4 or .5 meters in length.

When the rails are of the T-head pattern the rail and a cross tie can be both broken at the same time by applying to the rail, immediately above the tie, a charge of four petards formed by the superposition of two charges such as have just been described, firmly lashed together. The tie will be cut and the break in the rail will be about 1 meter long.

The damage produced by a single break is not always sufficient, however, to cause a derailment and it is better therefore to make two single breaks, that is to say, a *double break*. This is accomplished by placing on opposite sides of the same cross tie and at a distance of 1.5 meters from each other two charges of two petards each. One of these charges is placed on the interior of the rail and the other on the exterior (Fig. 33, Plate X). The two charges should be connected by a detonating fuze and only one of them need be primed. In this manner two single breaks are produced simultaneously and about 1.8 meters of the rail will be destroyed. Two charges, placed as just described, constitute a *couple de cavalerie.*

If detonating fuze is not available the two charges should be primed with fuzes that should be of the same length and that should be lighted at the same time. It is also essential to firmly secure the charges against the rail, since a failure of the two charges to explode simultaneously might lead to the displacement of the slower charge and a material decrease in its effect upon the rail.

When a more extensive destruction is desired a *couple* of two charges, each composed of two petards, may be placed on each side of a rail joint as has just been described, and the operation may be repeated at the next joint. With T-headed rails two charges of four petards each may be used for breaking simultaneously both the rail and the tie as has been described above. The two charges should be placed upon two ties that are not adjacent to each other.

TRACK DEMOLITIONS.

A single break of a track is obtained by placing opposite each other upon both lines of rails two of the charges previously described for single breaks.

A double break is effected by two double break charges (Fig. 34, Plate X). In both cases one charge only is primed, but the two charges are connected by a detonating fuze.

FOREIGN RAILROADS.

The methods described above for producing single and double breaks of rails and tracks may be applied to foreign systems. Some foreign

Plate X.

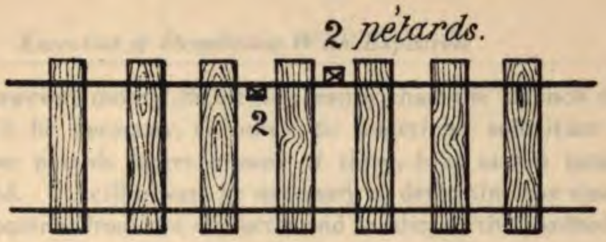

Fig. 33.

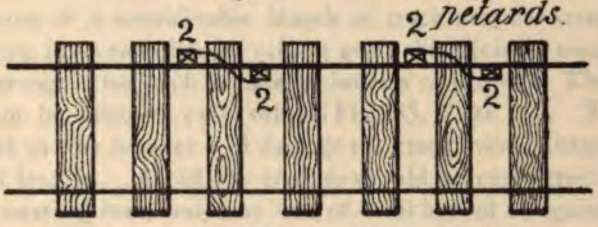

Fig. 34.

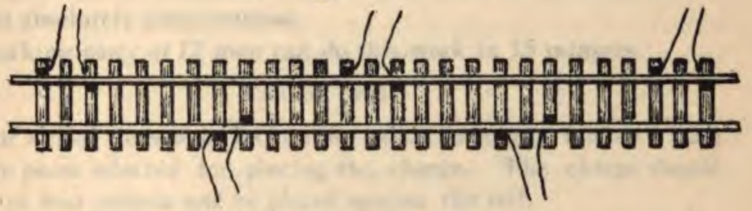

Fig. 35.

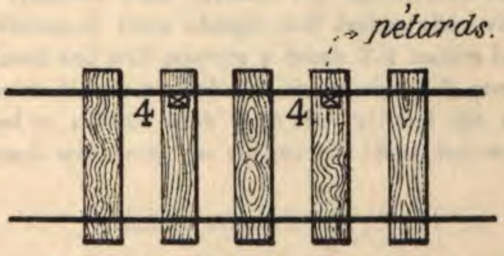

Fig. 36.

tracks are, however, more difficult to destroy than the French railways. It will be necessary, therefore, to sometimes substitute for charges of two petards larger groups of three, four or five petards properly placed. It will always be necessary to determine the size of the charges required from the character and solidity of the roadbed in each particular case.

DEMOLITION OF A LENGTH OF TRACK.

The destruction of a considerable length of track may be accomplished by placing upon each line of rails at every third joint a couple of charges so arranged that each couple includes a rail joint. These joints should not be opposite each other (Fig. 35, Plate X). Ten couples arranged in this manner will damage the track over a distance equal to 15 rail lengths. All of the charges should be connected together by a detonating fuze, only one end of which need be ignited.

If a detonating fuze is not to be had, each couple should be primed with a Bickford fuze whose length should be sufficient to give the men ample time to withdraw, and should be such as to make the explosions absolutely simultaneous.

A working party of 12 men can do this work in 15 minutes.

CROSS TIES.

When a cross tie is to be broken the ballast should be removed from it at the point selected for placing the charge. The charge should consist of four petards and be placed against the rail.

To cause a double break (two cross ties) two charges, composed of four petards each, should be placed along the inside of the rail upon two ties that are not adjacent to each other (Fig. 36, Plate X). The ballast should be removed from beneath the tie directly under the charge. The explosion of these charges will destroy the two ties on which they are placed and will produce a break 2.4 meters long. If the track is laid with double headed rails the chairs will prevent the charge being placed in contact with both the rail and the ties. A charge of four petards will break the tie and the chair but will leave the rail intact.

SPECIAL POINTS.

A switch may be destroyed by placing a charge of two petards between and in contact with the moveable rail of the switch and the rail of the main line. The destruction may be made complete by breaking the switch lever with one petard (Fig. 37, Plate XI).

A railroad frog may be destroyed by detonating simultaneously two charges of 3 petards each, one of the charges being placed at the point of the frog and the other at the angles of the guard rails that enclose this point.

Both tracks at a junction point may be destroyed by placing three or four petards between the wing rails and the point of the frog (Fig. 38, Plate XI), at the point where the thickness of metal is double that of the rail. Two other charges of two petards each should be applied in the usual manner to the adjacent rails at the point where these two rails have the least distance between them.

A turntable may be destroyed by rotating it slightly so that its rails are not in line with those of the track and, after raising a part of the floor, detonating a charge of two petards upon the roller ring or a charge of four petards in contact with the axis of the table.

A rotating draw span may be destroyed by a charge of two petards placed upon a pinion, cog wheel, the rollers or the roller ring.

The Saxby maneuvering mechanism, the signals, etc., may be broken by a charge of one or two petards. The fixed part of the signals may be disabled by a petard placed upon the axis of rotation. The damage may, however, be limited to cutting the connecting wire or chain, by means of which the disk is operated from a distance, and by removing this mechanism.

ROLLING STOCK, ETC.

The detonation of 1 petard placed against the plates of a tank will be sufficient to cause a break at the point of contact and to make a hole having a diameter of .1 meters. The rifle bullet, model of 1886, will also penetrate such plates.

To disable entirely these tanks the valve mechanism should be destroyed. This may be ordinarily accomplished quickly by breaking the cover to the chamber in which this valve is placed under the tank. Two petards will also be sufficient, if properly placed, to break the elbow between the valve and the standpipe or the supply and discharge pipes.

The character of the work to be done in disabling a locomotive will depend upon whether the damage is to be only temporary or is to be more serious. In the first case it will only be necessary to burst several boiler tubes by detonating in each tube one petard if the machine is cold, access being had to these tubes through the door upon the front of the locomotive.

Plate X

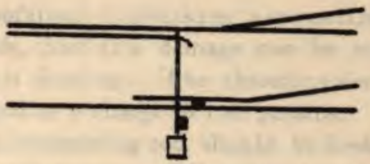

Fig. 37.

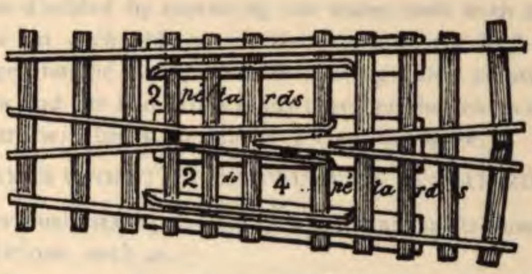

Fig. 38

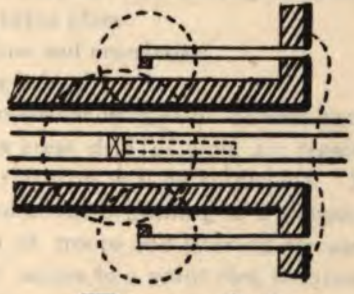

Fig. 39.

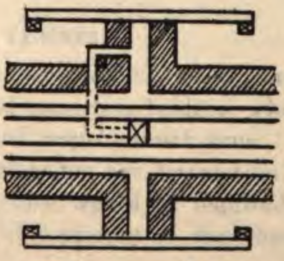

Fig. 40.

Better results may be obtained by breaking a connecting rod with a charge of three petards, and this damage can be accomplished even when the machine is fired up. The throttle valve or the injector may also be destroyed by a charge of two petards.

In the second case each connecting rod should be broken by four petards placed upon the crank bearing. The cylinders should be destroyed by a charge of five petards placed in close contact with them at some point, and petards should be detonated upon the eccentrics of the valve gear, lubricators, springs, suspension rods, etc.

A tender may be disabled by rupturing the water tank with one or two petards placed on each side or on the stems of the feed water valves. A carriage may be disabled by detonating three petards between the axle box and the band that holds together the leaves of the spring. One petard will break an axle or a coupling hook.

GENERAL REMARKS UPON THE DESTRUCTION OF RAILROADS.

As has been previously stated, special or particular points should be selected for demolitions, such as:—

1. Exterior rails on curved sections, where the centrifugal force will naturally tend to produce a derailment.
2. Deep cuts, for the purpose of producing a considerable obstruction when a derailment takes place.
3. Turnouts, junctions and crossings.
4. Turntables and switches.

Without destroying important bridges or tunnels such damage may be done as will require a great deal of time for repairs, and during this time the service of the road will be suspended. Minor demolitions are always employed at the beginning of a campaign in order to hinder the concentration of troops and later on are used for the purpose of preventing quick access to a point that requires protection, a tunnel that should be preserved or a station occupied as a post. They are, therefore, a sort of accessory defense and a means of preventing surprises.

TUNNELS.

Serious interruption of railroad traffic can be accomplished only by the destruction of tunnels and important bridges, whose repair or replacement will be difficult and require much time. It is ordinarily impossible to use high explosives for the destruction of tunnels, on account of the large quantity that would be required. Should such explosives be used, however, the amount of the charge may be determined from the formula, $C=4H^3$, in which H is the distance in meters from the charge to the interior face of the tunnel. Even with gunpowder it is possible to only partially destroy tunnels with improvised works, especially when they are excavated through rock. The damage is therefore generally limited to blowing up the portals, the most accessible parts. Under stress of circumstances the work may be even restricted to the destruction of the portal furthest from the enemy, thereby requiring him to travel the entire length of the tunnel in order to clear the obstructed end.

The speediest demolition with improvised works may be obtained by placing three mines, the first of which should be charged with 1,000 kilograms and located above the arch, 20 or 25 meters from the face of the portal and 6 meters from the intrados of the tunnel. The other two, containing 600 kilograms each, should be placed behind the two side walls, 15 or 20 meters from the face of the portal, 4 meters above the rail and about 5 meters from the interior face of the walls. These are known as mines for partial demolition (Fig. 39, Plate XI).

Mines for total demolitions are located well within the tunnel and include five charges, of which four contain 600 kilograms each and are placed behind the sidewalls, while the fifth contains 1,000 kilograms and is placed above the arch (Fig. 40, Plate XI).

A charge of 10,000 kilograms of gunpowder may also be placed underneath the tunnel near its central point and close to the lining. Such a charge may be replaced by 2,000 kilograms of melinite.

A temporary obstruction may be produced by dropping into the air shafts any material that may be readily accessible.

HOUSES.

A house of ordinary size may be demolished by placing on the ground floor a charge of melinite amounting to 500 grams per cubic meter of interior contents, all of the openings having been closed. This charge may be placed in one or more heaps, depending upon the arrangement of the house. When several charges are used they should be exploded simultaneously.

Elongated charges of 1.5 kilograms per linear meter may also be used at the foot of the partition walls or the panels between openings. All openings should also be closed in this case.

The walls may also be breached from the outside by an elongated charge of 4 kilograms of melinite per linear meter. When gunpowder is used, with a limited supply of powder and plenty of time, the charges should be placed in the panels between openings and their size determined by the formulas previously given for isolated walls. If, on the contrary, there is plenty of powder available and very little time, the charge necessary for a total demolition is determined and mine chambers are dispensed with. After determining the charge in this manner, it is increased by one-half and placed in a cellar or on the ground floor in several heaps connected by trains of powder. All the openings should be closed. The amount of the charge can also be calculated in this case by dividing the length of the front and side walls by 6 or 8 times the thickness, e, of the thickest of these walls and multiplying the quotient by a weight equal to $22e^3$. When the walls are thick or the buildings arched the mines should be placed, as previously described for isolated walls, in the foundations under the corners and the panels between openings. Shafts may also be excavated to a point below the foundations.

The walls may be also breached from the exterior by placing along the foot of them sacks of powder forming a charge of 15 to 20 kilograms per linear meter. The destruction of a group of houses may be effected by using fire in connection with large amounts of gunpowder.

FIELD WORKS.

To destroy rapidly a field work of which we have control it is necessary only to prepare in the parapet a mine with a chamber large enough to contain 150 kilograms of gunpowder.

INFERNAL MACHINES.

The destruction of the enemy's bridges when it is not possible to get near to them may be attempted by setting adrift in the current of the stream either infernal machines or buoyant mines containing explosive charges and so designed as to explode the instant they reach the bridge. Different methods are employed to fire the charge. One of the simplest methods is to use a form of alarm clock so arranged as to release at the proper moment a spring placed above a percussion cap. Use may be also made of a rod attached to the machine in such a way that it will oscillate upon striking the flooring of the bridge, the oscillation being transmitted in such a way as to fire the charge.

In another method two casks are placed one within the other with an interval between them that is filled with potters' clay or some other impermeable material. The gunpowder or other explosive for the destruction of the bridge is placed within the inner cask. The charge is provided either with a detonator primed with a Bickford fuze or with a slow fuze.

All of these machines have the disadvantage of being easily avoided by means of booms or pile barricades that deflect them from the bridge, or by guard boats that perform the same duty.

Works of this character can, moreover, be prepared at leisure, and there is no necessity of going further into the subject at this time.

WORKS FOR THE IMPROVEMENT OF NAVIGATION.

Should it become necessary to interrupt navigation upon a stream it may be accomplished by destroying, by the method previously described, the various works used for its improvement, such as dams, weirs, dikes, locks, etc. Navigation may also be obstructed by sunken boats, booms and other obstacles of the same character. Obstructions of the latter character may be removed by means of torpedoes or submerged mines when navigation is to be resumed.

AUTOMATIC MINE.

The insurgents in Cuba employed a very simple machine for automatically exploding a mine under a moving train. The following description of this machine, known as the Roqué torpedo, is taken from the *Memorial de Ingenioros* of February, 1898. It was successfully used on several occasions.

A ratchet wheel, R, is mounted loosely upon an axis formed by a flat headed wood screw, V, and within a wooden box with a moveable cover (Fig. 41, Plate XII). The rod, T, carries a pawl and has a motion in a groove parallel to the plane of the wheel, the spring, C, opposing the motion of the rod and pawl. The passage of the car wheels in succession over the rod, T, gives it a reciprocating rectilinear motion that is transformed into a progressive rotation of the ratchet wheel, R, by means of the pawl, D. When this wheel has advanced a certain number of teeth, the lug, E, comes in contact with the trigger, F, and depresses it, releasing the catch, G, of the firing pin, P, which is driven by a spiral spring against the primer, I. The explosion is communicated to a charge placed under the ballast.

The machine can be regulated so as to produce the explosion after the passage of *n* wheels. For this purpose the teeth of the ratchet wheel are numbered from a point corresponding to the lug, E. Before the explosion can be produced the wheel must be revolved so as to bring the tooth marked *n* opposite the end of the catch, G.

Plate XII.

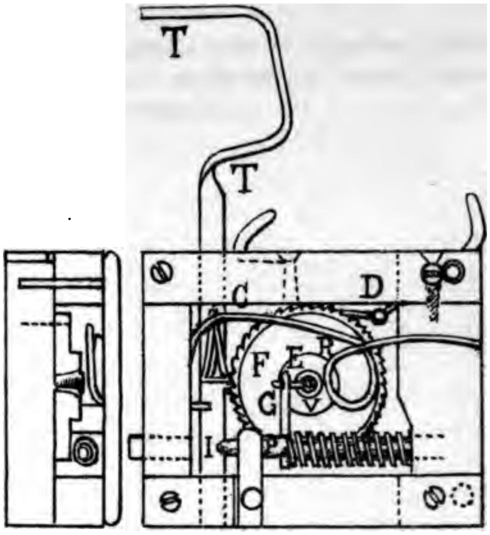

Fig. 41.

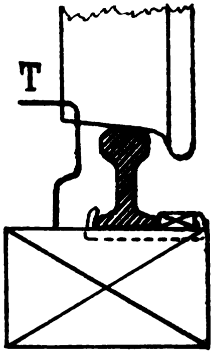

Fig. 42.

To the top of the box is secured a strap of iron that is bent up at both ends so as to enclose the base of the rail, to which it is attached by means of a wedge (Fig. 42, Plate XII).

CHAPTER VI.

CONCLUSION.

THE IMPORTANCE OF DEMOLITIONS.

As a general conclusion, it must be acknowledged that the destruction of obstacles in campaign will be of more importance than heretofore, mainly for the reason that high explosives have rendered more easy the execution of demolitions on a very large scale. It should, however, at the same time be stated that the necessary steps have not been generally taken, for making available the means necessary for executing these demolitions with modern methods.

Indeed, reference has been previously made to the fact that in the infantry and cavalry only special men in very limited numbers receive suitable instruction in this work and that the means for this instruction, explosives, are too parsimoniously issued.

Moreover, the general rules and the principles to be followed in such work are too vague and too widely scattered. Under article 108 of the regulations for troops in campaign, and under the provisional instructions of December 24, 1896, for cavalry in campaign, a detachment commander who is entrusted with the execution of a demolition divides his detachment into two parts upon arriving at the given location, but no information or general instructions are given with regard to the disposition to be made of these two parties. The most important of these two parties is entrusted with the security of the command and the other with the execution of the demolition, in which it must *act according to circumstances.*

PRACTICAL KNOWLEDGE.

It is important, therefore, that detachment commanders should be informed as to the results that may be obtained with the means at their disposal and as to the methods to be followed in executing demolitions that may be entrusted to them. It is essential that all officers should be as fully informed as possible upon the effects of explosives and of the methods of executing demolitions, but it is still more important that they should have such practical experience in this work as will create a personnel thoroughly trained in its supervision as well as in its execution. Operations of this character should be as familiar as any other drill and to the largest possible number of men. They occur almost every day during a campaign and it is necessary that they should be executed readily, ***acting according to circumstances***, and with the widest possible previous study of all of such circumstances as are apt to be found in actual service.

For these reasons and for assuring the instruction of the men, Austria requires the execution annually by each company of engineers and of pioneers of a drill for the demolition of an iron bridge under campaign conditions, using simulated charges and appliances. Moreover, each instruction district is provided with wooden models of various types of iron bridges with charges and firing connections in place, all of full size.

This system should be followed for all troops that may be required to execute demolitions in order that they may become acquainted with conditions approaching as nearly as possible to those with which they will actually have to do and at no great resulting expense. Nevertheless, actual practice is indispensable and this has been very efficiently provided for in cavalry regiments, which have at their disposal the necessary material for instruction in barracks and during maneuvers and are also provided with petards, detonators, etc., for executing annually the actual firing of charges.

DISTINCTIONS TO BE MADE AS TO DEMOLITIONS.

In conclusion it is essential to note the following marked differences in the different demolitions that may arise in campaign:—

1. Demolitions of slight importance and of daily occurrence, such as the cutting of a highway or railroad, the re-establishment of communications, the breaching of a line of works requiring very few men, the placing of a few charges under conditions of little difficulty and such as can be executed by troops of all arms who have been previously and suitably instructed in this special work.
2. Demolitions of important structures which can be executed only by engineer troops or at least under the direction of engineer officers.

As a matter of fact, the first are much more common, but cases may arise in which the troops entrusted with their execution have not the necessary facilities. For instance, a cavalry scouting party may not be equipped for the execution of important demolitions in advance of the army. It would therefore become necessary to attach to them at such times detachments of engineers provided with the necessary appliances and the speediest means of transportation for reaching the desired points. There should perhaps be organized for such work either mounted detachments of engineer pioneers or at least bicycle detachments.

An endeavor has been made to group together and to properly arrange in the best possible manner everything relating to this important question of demolitions, making use of all official and other documents that have appeared upon the subject. A close study of the subject has made it apparent that while a great deal of attention has been given to the means of reaching a solution there is room perhaps for improvements in the equipment of existing organizations by the addition of many indispensable adjuncts. A pronounced advance in this direction has been made for cavalry regiments, and very beneficial results would no doubt be had by extending the same facilities to the infantry.

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UNITED STATES ARMY.

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TRANSLATION OF PAPER ON THE EFFECT OF LIMITING THE SERVICE OF ENGINEER TROOPS IN THE FRENCH ARMY TO TWO YEARS

FROM THE JOURNAL DES SCIENCES MILITARIES, FOR SEPTEMBER, 1904

TRANSLATED BY
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WASHINGTON BARRACKS, D. C.
PRESS OF THE ENGINEER SCHOOL,
1904.

THE EFFECT OF TWO-YEAR SERVICE ON THE ENGINEER TROOPS.

[From the Journal des Sciences Militaries, for September, 1904.]

Translated by LIEUTENANT W. D. A. ANDERSON, *Corps of Engineers.*

One of the principal results of the two-year law which is about to come into force will be that the course of instruction now given to the enlisted men must be cut down. This point is generally admitted; and indeed it is with this in view that the last infantry drill regulations seem to have been gotten out. The question of providing for this change now comes up. For the engineers it is more complex than for any of the other branches on account of the greater number and variety of their duties.

It will not be enough to cut out certain subjects no longer considered necessary for the soldier's instruction; experience proves that recourse must be had to a general reorganization in which the units will be grouped according to their duties—will, in fact, be specialized, just as we have seen already in the successive formation of the railway regiment, the telegraph battalion, and the balloon battalion from elements previously scattered among the different engineer regiments.

Indeed, if we wish the efficiency of the engineers to be unimpaired by the shock of the change that will inevitably take place in all arms of the service when the two-year law comes in force, the steps to take are clear, and the first is to specialize as far as possible. It is so much the more important to do this because at present the condition of the engineers, except those recently specialized, is not at all what could be desired.

This is, moreover, the impression derived from reading over the law of February 10, 1900, for the instruction of the engineer sapper regiments, in which it is implied that a satisfactory result is obtained if at the end of the year's course of drill and engineer work one-fifth or one-sixth of the men in each company are reported qualified as first-class miners or pontoneers.

There are other apparently insignificant facts which also tend to confirm the opinion above expressed. For instance, on the official army register, published periodically, all or nearly all of the engineer regiments are always shown as not having the number of reenlisted N. C. O's allowed by law. This is due to many causes, but nevertheless shows a condition peculiar to the engineers, the more to be regretted as it was not formerly the case. Indeed, at a time still remembered by many, nearly all of the engineer N. C. O's reenlisted; and that too when they were offered neither a money reward, nor a promise of civil service position, nor increased clothing allowance, nor the other advantages now offered; and, on the other hand, officers were no more considerate of their subordinates then than now.

The time has now come, from every point of view, to proceed as far as present conditions permit in the reorganization of the regiments of sappers, which constitute the greater part of the engineer troops, and which stand in real need of it. This reorganization, planned and carried out as above indicated, consists in grouping the elements, now scattered through the regiments, according to their duties and to the instruction which must be given to each. This can be done by separating the troops classed as sappers into two classes; the one charged with permanent fortifications and the other with field work.

It might be desirable to form a third class comprising those especially instructed in military bridges. It is, indeed, well known that a provision of this sort was embodied in the Army Reorganization Bill of March 18, 1875, by the committee in charge of the bill, and that in turning over the ponton service to the engineers it was also proposed to give them the two ponton regiments whose organization was asked for. But it is also well known that the National Assembly, moved by considerations foreign to the question, failed to ratify the bill reported by its committee. The question has, however, been again taken up lately, and many well-known military writers are advocating a return to the organization provided for in the bill of 1875, and the reestablishment of the two regiments of pontoneers which were suppressed when it was decided to transfer the ponton service to the engineers.

This plan agrees too well with our ideas on the specialization of the duties of the engineers for us to reject it off-hand. Its authors, moreover, support it with forcible arguments which cannot be gain-said. They call attention, for one thing, to the fact that we have in France but one stream, the Rhone, on which there is sufficient room for ponton drill, and also that we could not permanently concentrate upon this river all the engineer troops intended for field service without serious inconvenience. They consider, too, that with two years service it is uncertain whether the practical course of instruction that regularly takes place on the Rhone will be enough to properly instruct the men. And lastly they point out that the necessary transportation of the troops taking part in the drill causes loss of time for the men and great expense for the government.

As to this travel, it might be said that the engineers are no worse off than the other services, for very few organizations can finish their courses of instruction without going some distance from their garrisons, as is shown by the formation of the camps of instruction. On the other hand we believe that the new organization proposed will provide for the first effects of the two-year law and, in the case in question, will allow more time for special drills, thus giving each man as many hours at these as he now has in the three-year service.

It is to be regretted that the bridge on the Rhone during the last maneuvers of the 14th and 15th corps was built by the companies of the Avignon regiment instead of by details from the other regiments of engineers, for we believe that various interesting and instructive points could then have been deduced from the experience.

The most serious objection, however, to the proposition just announced is this: The strength of the units assigned to the various special services is reduced not only to the lowest safe figure, but even further, as we shall see later; so that it would be necessary to furnish a complete equipment for the two new regiments of pontoneers. This would be a considerable expense, requiring an appropriation that cannot be expected at present.

In short, however attractive and desirable the plan we have been discussing may be, we do not believe it will be accepted, at least not at present, because the other engineer services are in a much more unsatisfactory condition and must be relieved first of all.

We must limit ourselves, therefore, to the two classes mentioned above. With regard to the organization in detail of the elements which compose them, we shall begin with that of the fortress troops.

In proposing to make these a special group we are really returning to the old companies of miners which were classed as engineers from their first organization and were in existence at the time of Vauban and before. The law of 1875 abolished them on the grounds that many occasions had proved that the companies of miners and of sappers had become interchangeable, particularly the war of mines carried on during the siege of Sevastopol; and also on the grounds that, while the regimental course of instruction was not the same, the difference was so slight and the line of demarcation so fine that it could be broken without the least embarrassment. This theory could be easily sustained in 1875, but not so now, as can best be seen by referring to the regulations of February 10, 1904.

While suppressing the regiments of miners the Assembly of 1875 could not at the same time abolish the special duties with which they were charged. It was provided that out of the twenty battalions provided for, the twentieth, plus the fourth company of each of the nineteen others should be considered as fortress troops, thus giving a total of twenty-three companies. It was, however, provided that from this total there should be deducted the three companies permanently assigned to the defense of Algeria, and also that an undetermined number of them might in time of war be attached to the army engineer trains. They came to be considered as a disposable reserve to be drawn on at will, as shown in the formation of the railroad regiment, which absorbed the twentieth battalion, and similarly in the formation of other special bodies, with the result that out of the twenty-three companies not half are left to-day.

The new organization which we propose will restore the original plan, for we are counting only on resuming the number of companies provided for in the law of 1875, deducting therefrom the three assigned to Algeria, whose work is already laid out. We count then on a total of twenty companies, too few rather than too many in comparison with the number and size of our fortified places. The greater part of the garrisons is, of course, to be composed of units drawn from the reserve or from the territorial army. But we must not count too much on this, for the organization of these units will not be possible unless enough men can be found among the reserves and territorial forces who have received the necessary training during their service in the active army. Consequently it is more important for the latter to be prepared to give them this training.

As to the organization of the above twenty companies, we might group them into two regiments, as in the case of the pontoneers, one of these regiments having charge of the fortified places of the Northeast from Dunkirk to Lyon, and the other those of the Southeast from Lyon to the Mediterranean. The companies of miners would thus form a true subdivision of the engineers and could be drilled and subsisted without the need of a temporary organization composed of detachments drawn from the various regiments, as was formerly the case. But here again we run up against the terrible question of money.

On account of this question of appropriations we must then find some more modest plan, less costly, and more easily adapted to the present organization.

This plan consists in forming a special battalion in each of the regiments of sappers except the fifth, and in making these as independent as possible in their drill. We should then have six battalions, comprising twenty companies, including of course those companies detached for special fortifications, whose stations would not be changed. Each of these battalions would bear the number of its regiment, the companies being numbered serially from one to twenty.

This plan implies the retention of the present regiments, which would be called simply regiments of engineers, as is generally done already. We do not ignore the fact that the advantages of the regimental organization for the engineers has been disputed. The discussion of this point, however, is foreign to our subject, since it has already been decided by those in authority. Moreover, we must confess that we believe it would be a serious mistake to give up this formation in view of the fact that, in addition to other good points, it offers such excellent opportunities for the instruction of the officers; a matter to be considered as much as that of the enlisted men.

This being settled we come to the question of the organization of the units in the second class; *i. e.*, that of the sapper-pontoneers, charged with the field work. This would be practically settled if the organization of the army corps and of the engineer battalions assigned to each of them remained the same as was provided for in the General Reorganization Bill and the Army Bill of 1875. But this is not the case, as now under a law of a few years back the Minister of War has authority to distribute the companies among the battalions according to the needs of the service, so that the battalions no longer have their normal composition.

This law certainly has its advantages in some cases, but it presents the serious disadvantage of legalizing this dangerous method, which is in effect "robbing Peter to pay Paul." As a result two battalions, the sixth and the twentieth are each one company short, at a time when these battalions form part of the frontier guard, which should always be ready to march at a moment's notice.

The law in question should be repealed as soon as possible and replaced by one providing that each of the battalions of sapper-pontoneers have one company for corps duty and as many companies for division duty as there are divisions, or equivalent units, forming the corps to which the battalion is assigned. This provision is elastic enough to allow the Minister of War to form new companies or to suppress those no longer needed, whenever cause arises, without having to wait for a special law. At the same time, in urgent cases he would have at his disposal the nineteenth battalion which has no permanent assignment and could therefore be temporarily assigned.

With regard to the present organization, the composition of the battalions would be as follows: Five battalions, the 6th, 7th, 14th, 15th, and 19th, would each have four companies, the others would have only three, giving a total of sixty-five companies.

It is probably of interest to note here that the strength of the engineer regiments has been fixed in a very arbitrary manner only, and that this was the case when the War of 1870 broke out. To prove this we have only to refer to a note on the organization of the army written by Napoleon I, and dated October 6th, 1810, which should be found in the archives of the War Department. In it the Emperor says, "that each division of infantry should have its company of sappers, and in addition each army corps should be given four others, three of sappers and one of pontoneers." This allowance is almost double what we have to-day; and that too when the work and duties assigned to the engineers have not decreased, but rather the contrary.

Finally, we believe that a protest should be made against a plan, lately brought forward, to take away from a part of the engineers the name sappers, which they have rendered famous on so many battlefields, and to give them the name pioneers, by which such troops are known in Austria and Germany.

This last name, which is French or at least Gallicized, has not in itself, certainly, anything opprobrious. But the supporters of the measure seem to ignore, or forget, that this name is given in our army to a body of troops recruited from among the worst elements of the punishment companies and from the dregs of society. It would take years to remove the stain of infamy that clings to the name. Of what use can such a change be, when no confusion is caused by the present name, and when there is not a soldier in the army, no matter whether engineer, infantry, or cavalry, who does not know what you are talking of when you speak to him of sappers?

To sum up, if a few changes in organization were carried out as outlined above, the enginer troops which, if we are right, have now 105 companies would then have 120 companies, namely:

20 companies of miners, (*sapeur-mineurs.*)
65 companies of sapper-pontoneers, (*sappeur-pontonniers.*)
12 companies of railroad troops, (*sapeurs de chemins-de-fer.*)
6 companies of telegraph troops, (*sapeur-telegraphistes.*)
4 companies of balloon troops, (*sapeur-aerostiers.*)
7 companies of engineer teamsters, (*sapeur-conducteurs.*)
6 companies of the Algeria battalion, (*bataillon d' Algerie.*)

There would be an increase of 15 companies, which would fall largely in the first two of the above divisions, and especially in the miners.

We investigated the effect which this organization would have on the budget and have become practically certain that it will not form an insurmountable difficulty. It is possible indeed, so far as the officers are concerned and by means of certain changes in minor details, to put the new organizations in force without exceeding the maximums established by the present law. This organization, it is true, would be only temporary, but it could be kept up as long as seemed desirable and would furnish a groundwork on which to build up gradually to the organization finally decided upon.

As to the enlisted men, whose strength would be increased by about 1,700 men, it is evident that they could be gotten only at the expense of the other arms, since the contingents are now embodied as a total. If these men could be taken equally from all the regiments of the army the number taken from each would be very small; and it would be still less noticeable if they were taken principally from the staff corps, whose force, it seems to us, is much larger than necessary and should in any event be recruited exclusively (as seems about to be done) from the men put in the non-combatant services by the recruiting boards on account of slight physical defects. Moreover, so long as a man is in the foot service there is no distinction made in the budget as to whether he is assigned to one corps or to another. So we see that the principal measures to be adopted in preparation for the two-year law can be put in force easily and, what is most important, without causing appreciable change in the present organization of the engineers. This, though, does not mean that everything will be settled; on the contrary there still remain many other questions brought up by and bearing more or less directly on the new recruiting law.

Among these questions is one too closely related to the above to be passed over without comment; namely, whether the specialization given to the enlisted men should be applied also to the officers of the engineers. We believe that the answer should be most emphatically "No," as not a single instance under present conditions can be cited in which our officers have shown themselves unable, on account of either mental or physical deficiency, to perform the multitude of duties which to-day fall to their lot. We have, to be sure, often heard men say that it is impossible for a man to be at the sametime an officer, a military engineer, a civil engineer, an architect, an electrician, and so on. That is a fine subject for academic discussion, but it can easily be reduced to naught—merely by citing the facts as they stand.

We know too that in the German army the matter has been differently settled. But not to enter on a line which would take us too far afield, we limit ourselves to noting that the difference in conditions justifies the difference between our method and theirs.

CASIONAL [illegible]RS,
ENGINEER SCHOOL,
UNITED STATES ARMY.

A Brief History of Works Erected for the Defense of Portland, Maine

By C. F. PORTER

WASHINGTON BARRACKS, D. C.,
PRESS OF THE ENGINEER SCHOOL,
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WASHINGTON BARRACKS, D. C.,
PRESS OF THE ENGINEER SCHOOL,
1905.

1st Indorsement.

U. S. ENGINEER OFFICE,
PORTLAND, MAINE,
April 23, 1904.

Respectfully transmitted to the Chief of Engineers, War Department.

This paper has grown out of the quest for facts of history to be supplied to post commanders for entry in the post record books.

Mr. Porter[†] has always looked up the desired information as far as the office records could give it, and becoming interested in the subject, has extended his research along other lines. The paper is the result of his investigation along these lines.

Though not a complete history of the fortifications, it contains much information of value and interest to those who are and have been identified with the forts in this harbor. * * *

The fortification records of this district were destroyed in the great fire of 1866,

S. W. ROESSLER,
Major, Corps of Engineers.

2d Indorsement.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF ENGINEERS,
WASHINGTON,
May 2, 1904.

1. Respectfully referred to Major Edward Burr, Corps of Engineers.

2. It is thought the accompanying historical sketch is worth printing as a School Paper, and it is requested that an edition of 300 copies be so printed. * * * All information regarding work done since 1890 should be omitted, and a note should be added stating that such omission has been made. * * *

BY COMMAND OF BRIGADIER GENERAL MACKENZIE:

FREDERIC V. ABBOT,
Major, Corps of Engineers.

[†] Chief Clerk in the Portland Office.

A BRIEF HISTORY OF THE WORKS ERECTED FOR THE DEFENSE OF PORTLAND, MAINE

Portland was first settled in 1632, by George Cleeves and Richard Tucker. The ancient Indian name was Machigonne. It was at one time called Casco, subsequently Falmouth, and finally Portland. In earlier records and histories frequent allusion to the locality is made under the title of the "Neck" or "Great Neck." The settlement was entirely destroyed in 1676 during the first Indian war, resettled in 1680; again destroyed by the French and Indians in 1690, and resettled anew, so that by 1713 it had regained something of its early prosperity.

October 18, 1775, the town suffered bombardment by a British fleet under Captain Mowatt, and almost completely destroyed.

The earliest record of any defensive work in Portland Harbor recites that in 1676 a fort was hastily thrown up on Fort (Cushing) Island, as a place of retreat from the Indians. Willis states that in 1865 there were the remains of a stone building on the island, and he probably supposed it was connected in some way with the early defenses. It appears that in 1675 and 1676 there was a garrison house (or Munjoy's Garrison) at the lower end of the Neck, where the inhabitants took refuge from the Indians. The eastern end of the peninsula is still commonly known as Munjoy Hill. In August, 1676, being unwilling to trust to this place of defense, the settlement being attacked by the Indians, the inhabitants fled to James Andrew's Island (Cushing) where they remained in dire peril until relieved by the arrival of a sloop which had been dispatched to their aid. It has been stated that the retreat to Cushing Island and the defense there were conducted under the leadership of Rev. George Burroughs. Mr. Burroughs was tried for witchcraft in Salem on May 8, 1692, was condemned, and was executed in August, following. Among the evidence brought against him was his extraordinary strength and activity, believed to have been derived from the prince of evil. It was proved that he had lifted a barrel of molasses by putting his fingers in the bung-hole, and that he had held a gun more than seven feet long at arms length with one hand.

There seems at this time also to have been a "fortified house" on Jewels Island. At this period the pay of a general of militia was six shillings, a captain five shillings, while privates received one shilling and six pence per day. Indian corn cost about three shillings per bushel, and a cow forty-five shillings.

In 1679 on return of the settlers, profiting by their experience, they at once built a fort, the first on record. The location selected was at the end of King (now India) street, about where the Grand Trunk station stands. It was on a rocky bluff about fifteen feet above the level of high water. The fort is described as consisting of a number of log buildings, surrounded by an outer barrier of fence in a palisade form on which were mounted towers for defense and observation. Its area was one-half an acre and it mounted eight guns. The name applied to the work was "Fort Loyall." For its erection the Massachusetts House gave one hundred pounds worth of land and in 1681 it determined that no less than thirteen men were needed for the garrison, a captain, sergeant, gunner, and ten private soldiers. The wages of six of these were paid by the province, the colony caring for the others. The commander was Captain Tyng, who was in 1681 voted his annual pay of sixty pounds for himself and servant. In 1682 a contract was made with Left. Anthony Brackett to take charge of and keep the fort, furnishing six men as garrison in summer, and four men in winter, for the sum of one hundred and sixty pounds for one year, which expense was raised chiefly by a new tax on saw mills. An old record states that here "at Fort Loyall, 23d of September, 1680, house lots were granted upon the neck of land near the fort," compactly located for better defense against the savage enemy. Thereafter Massachusetts pursued a more liberal policy, assuming the whole burden of the fort, and at one time went so far as to bestow "one barrel of powder, of the meanest of the country's store and worst."

In 1685 Fort Loyall was appointed also as a prison or jail for the associate towns of Saco, Scarborough, Falmouth and North Yarmouth. It is recorded that in 1690 there were four garrison houses; one on Munjoy Hill near the burying ground, and one at the foot of Exchange street. The other two cannot be located.

For ten years Fort Loyall quieted the fears of the settlement, but in 1690 the French and Indians attacked the town, routed the men from the garrisons, set fire to the houses, and besieged the fort where two hundred people, of whom perhaps seventy were fighting men, had taken refuge. This was on May 20, 1690. For five days and four nights the battle waged, when the enemy gaining a position at the foot of the bluff beneath the fire of the guns, advanced a mine near to the walls. The garrison, under Captain Davis, after some parley, surrendered. Two hundred persons yielded, of whom it is stated that perhaps a dozen escaped with their lives down the coast to Wells, and Falmouth was again desolate. The armament at this time is not given, but it is recorded that the cannon were too large for Indian transportation, and were recovered two years later by an expedition under Sir William Phipps and Major Church, at which time the bleached bones of those who had fallen in the defense, were buried.

In 1699 settlers again began to return, but they now gathered near the mouth of Presumpscot river. Old Casco was desolate, and the new one was called New Casco. In 1700 under an order of the Massachusetts General Court a new fort was erected on a point east of the Presumpscot, called Fort Point. It has been described as an oblong square of 250 feet in length and of 190 feet in breadth, the bastion not included. The covered way to the block house on the shore was 230 feet in length. At the rear corners were watch towers, and at the front larger bastions. The "oblong square" was of wood and a good thousand feet in circumference. In 1703 it is stated that it was enlarged, and beds and bedding were for the first time furnished by the Government. During this year it was besieged by a force of five hundred French and Indians who began to undermine the fort from the water side from a position beneath the fire of the guns. After two days and nights they had nearly succeeded, when the garrison, consisting of thirty-six men, was relieved by the arrival of a province armed vessel. The fort was garrisoned more or less effectively until 1716 in which year it was abandoned and demolished by order of the Massachusetts House of Representatives. For more than a century its ruins were traceable.

In 1727 eight families settled at Pond Cove and built a garrison for their defense.

After the abandonment of Fort Casco in 1716, the remaining settlers, consisting of fifteen men besides women and children betook themselves to the Neck. This again became the center and in 1718 became dignified by the name of Falmouth. For twenty-three years they got along without defense except "Moody's garrison on the Neck at the east corner of Hancock street, and perhaps one or two others in different parts of the town."

In April 1742 the Government ordered a breastwork and platform for ten 12-pounders to be built on the Neck, for the defense of the harbor, and appropriated four hundred pounds to pay the expense, the labor and stores to be furnished by the town. The work, which probably also included a wooden blockhouse with ports, was erected on the site of old Fort Loyall, destroyed some fifty years before, on the bank on the eastern side of India street. It was built under the direction of Enoch Freeman, who afterwards commanded it. In 1744 eighty-five troops were posted in different garrisons of the town, two being stationed in Rev. Mr. Smith's house which had been used for a garrison some years before. During these years Indians were troublesome, and in 1746 a blockhouse and stockade were built near the site of the old city hall (Monument Square). In the fall of the same year, the town, in anticipation of an attack by a French fleet, voted to apply to Captain Moses Pearson for the use of his two great guns, to be placed on spring Point, and to get four barrels of powder, balls and flints for the use of the town.

In the spring of 1747 Indian hostilities and alarm being resumed three swivels were put into the Rev. Mr. Smith's house.

The fort at the foot of India street which had been repaired in 1742, having been neglected, was again placed in condition in 1755.

December 26, 1774, a committee was chosen to remove the cannon from the fort and secure them as they thought proper, and also the powder, balls and gun carriages belonging to the town. In the first four months of this year, five hundred and seventy-five pounds were assessed for the purchase of powder and other public charges. On the 23d of April, 1775, the Selectmen were authorized to borrow instantly one hundred and thirteen pounds, six shilllngs and eight pence to purchase powder. October 18, 1775, the town was bombarded by a British fleet under Captain Mowatt and practically destroyed. In November of the same year the British ship *Cerebus* appeared in the offing and the citizens worked desperately throwing up a "moon shaped" breastwork where the six-pounders were set in place.

There were also a battery and breastwork on the site of the Catholic convent on Free street, a battery and magazine at the Haymarket and County House, and, in 1776, a temporary fort of wood or stone at Spring Point (Fort Preble). It is stated that the guns that frightened off the *Cerebus* were mounted on the site of the lower battery (Fort Loyall). May 21, 1776, a committee was chosen to repair the forts on the Neck, one of which is stated to have been on Munjoy Hill, and the other on the hill in Free street. In June the General Court made provision for stationing a company of fifty soldiers here, for which they sent ten cannon. The command was given to Captain John Preble. In November another company of fifty men was stationed at Cape Elizabeth for the defense of the harbor, and with the one on the Neck, was continued in service until March.

In April, 1777, a company of eighty men, commanded by Abner Lowell, was stationed on the Neck, and another of forty men at Cape Elizabeth. The pay of a captain was six pounds per month, privates two pounds. September 3, 1779, three ships-of-war appearing in the offing the batteries were immediately and strongly manned. Three batteries were constructed "one on the hill in Free street, another, and the principal one, at the foot of India street, where Fort Loyall stood, and a third on the brow of Munjoy Hill." In the fortification at the foot of India street were placed one 18-pounder and three or four 12-pounders. The fears of the people were soon dissipated by the arrival of the American frigates *Boston* and *Dean* with a large prize ship. May 1, 1783, at a public celebration following receipt of news of the ratification of preliminary articles of peace several rounds of cannon, thirteen at each round, were fired, one man being killed by the bursting of a cannon.

In an account of his travels through the United States and Canada, 1795-97, Duke de la Rochefoucault, in referring to Portland, says:

"They are at present constructing on the site of an old earthen breastwork, a fortification, which they expect to command the town, and to render it at least secure from the invasion of an enemy. This new fortification stands at the extreme point of the peninsula on which Portland is established, and consists of a battery of fifteen or twenty heavy cannon, of large calibre, commanding that wide entrance of the bay which was above mentioned. This battery is to have by means of a covered way, a communication with a small fort at a distance of four or five hundred toises, which it has been thought necessary to erect on the highest part of the isthmus. The fort is sufficient to hold two hundred men."

In regard to the latter, Willis states:

"This refers to Fort Sumner which was commenced in 1794 under an appropriation made by the general government in that year for the defense of certain harbors. The barracks were erected on the sumnmit of Munjoy's Hill, surrounded by an earthen embankment beneath which was a deep, dry ditch. It was connected by a covered way with a battery erected on the southerly brow of the hill where Adams street now passes. Guns were mounted at both places, but the barracks for the accomodation of the men, and the parade ground, were within the enclosure on the hill. A company was stationed here for several years, and in 1809 it was the only fortified position in our harbor. * * * The fort and breastwork were kept up until after the War of 1812, when the forces were withdrawn and the works were suffered to go to decay. It was named for Increase Sumner, an honored Judge of the Supreme Court of Massachusetts, and Governor of the State from 1797 to his death in 1799."

It is believed the heavier works were at the present site of Fort Allen Park, and the smaller at or near where the Shailer School now stands, and the reference to the old earthen breastwork leads us to suppose that the works previously referred to as on Munjoy Hill, were at Fort Allen.

In 1794, Colonel Rochfortain, an engineer, was sent here to superintend the construction of fortifications.

Another account of these works states that: "After the consultation of engineers and town authorities a square work was laid out on the present site of Fort Sumner Park. A ditch was excavated on four sides; a wall of boulders fifteen feet high led from the bottom of this to the top of a parapet. It was surmounted by a palisade and entered on the southwest side. The plan of defense included a battery between the observatory and the burying ground, connected with the citadel by a covered way never built on account of the sandy soil." In 1830 Fort Sumner was sold to Hon. John Anderson for $50.

There is reference to Fort Burrows, named for the Commander of the *Enterprise*, and built by Massachusetts in 1813 on the site now occupied by the works of the Portland Company. The citizens of Portland built the barracks and contributed $10,000 for public defense. Another was Fort Lawrence, named for Captain Lawrence of the *Chesapeake*, built on Fish Point in 1814, and mounting five or six 42-pounders.

With the exception of Fort Preble (Spring Point) all the works referred to above have now ceased to exist. Fort Allen and Fort Sumner are at the date of this sketch (1904) used as public parks. At the former a line of earthwork is still maintained and two old pieces are kept for ornament.

At Fort Sumner the only warlike evidence is a small brass piece standing on the hill overlooking the town and the country to the westward.

This brings us down to those works which are still in existence, most of which are included in the present chain of defenses of Portland Harbor. No attempt will be made to show the growth of the reservations as the various acquisitions by the general government are given in detail in a publication entitled "Military Reservations, etc.," prepared in the office of the Judge Advocate General, U. S. Army, and issued in 1898.

FORT PREBLE.

The first permanent work at this site was built in 1808, and accommodated thirteen guns and a howitzer. It was a redoubt with a brick scarp enclosing the quarters of the garrison. An old record of Fort Preble states that the armament from the war of 1812-15 to 1842 was unknown, "but soon after (?) casting, in 1827-28-29, twelve 24-pounders were supplied, and remained; 10 in the main work and 2 in the S. E. battery until in July, 1861, the post was made Headquarters of the 17th Infantry, which found the above guns as stated, and one 8-inch Columbiad and one 8-inch Seacoast (Howitzer) both dismounted. No powder at the post and a small supply of 24-pounder shot and 8-inch shell."

The record of armament in the early part of 1842, shows only the twelve 24-pounders.

In 1845 two new batteries extending north and south from the redoubt, and mounting twelve and ten guns, respectively, were added. In 1863 a new work was commenced. Its plan contemplated a granite casemate battery of three tiers of guns—two in casemate, and one en barbette—exterior to the old lines, and following the general low water line. The scarp of four fronts was carried up to include the first tier of embrasures, operations being suspended at the close of 1867. In 1871 the old redoubt was modified and the batteries of 1845 extended. Some work was subsequently done on the north and south batteries. * * *

The post was named in honor of Commodore Preble.

FORT SCAMMEL.

In 1808 a wooden blockhouse was erected at Fort Scammel (House Island) named for Colonel Alexander Scammel of Revolutionary fame. It is said that the building was octagonal in shape, had a pointed roof, and on each side presented a port-hole and a gun. The upper story which projected two or three feet over the lower, contained the battery. The whole building was clapboarded and painted white. A rampart enclosed the work and barracks, and on the roof of the blockhouse was a carved wooden eagle.

An official record describes the work as a semi-circular battery, and a detached lunette northeast of it. In 1845 these works were connected so as to form an enclosed work. In 1862 the construction of the detached casemated bastions was commenced. Operations ceased in 1875. The old armament was disposed of in 1901. Appropriations for construction aggregated $680,900. In 1892 the local Board of Health was allowed to establish a quarantine station on the reservation. * * *

FORT GORGES.

The construction of this work was commenced in 1858 and for some years it was known simply as the "Fort on Hog Island Ledge." It was then designated as Fort Gorges in honor of Sir Ferdinando Gorges, the early proprietor of a large part of the State of Maine. The present granite casemated work represents all that was ever done at this locality. It is said that it was largely through the influence of Jefferson Davis, then Secretary of War, that legislation that made the building of the fort possible, was secured. It seems that he paid a visit to Portland in 1857, and, the account adds, "to the great rejoicing of the Democrats." Work was continued until the close of the season of 1876, and the fort practically completed. The appropriations for construction aggregated $840,000. The old armament was condemned and disposed of in 1901. * * *

FORT WILLIAMS.

For many years the works at Fort Williams were known as "Battery at Portland Head," and received their present designation in 1899, in honor of the late Brevet Major General Seth Williams, Assistant Adjutant General, U. S. Army.

The first land purchased was in 1872, when fourteen acres were bought for $2,800, or $200 per acre. To-day holders of land in that vicinity are not so modest. In 1873 work was commenced on the construction of a barbette battery to accommodate 29 guns of the heaviest caliber at that time in use. Work was suspended in 1876, none of the guns were ever placed, and with exception of the remains of two positions, the old works have been obliterated in the construction of modern emplacements. * * *

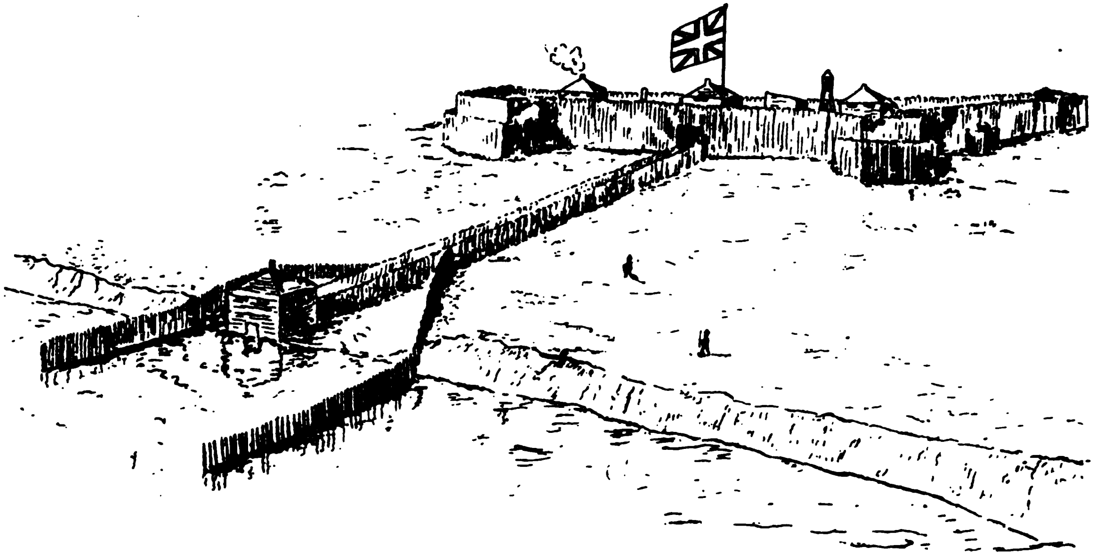
FORT GORGES was named for Sir Ferdinando Gorges, born in Somersetshire, England, at a place or manor called Ashton-Phillips, in 1573. It is said that he served in the Spanish expedition when Cadiz was taken in 1596, and was Governor of Plymouth in 1600. In July, 1637, he was appointed Governor General of New England. In 1639, he obtained his ample charter of the "Province of Maine." He died in 1647. It is recorded that for over forty years he engaged with energy and pursued with perserverance the work of discovery and colonization of the eastern shores of New England.

FORT SCAMMEL. Named for Alexander Scammel, Colonel, Revolutionary Army, born Mendon, Massachusetts, 24th of March, 1747; died Williamsburg, Virginia, 6th of October, 1781. Son of Dr. Samuel Leslie, who came to Boston from Portsmouth, England, in 1738, settled in Mendon (now Milford), and practised until his death in 1753. He taught school in Kingston and Plymouth, Massachusetts; was a surveyor at Portsmouth in 1772; taught school at Berwick; and was a proprietor of the town of Shapleigh, Maine; assisted Captain Holland in surveys for his map of New Hampshire; and in 1775 was a law student with General Sullivan, and his Brigade Major at Cambridge in 1775, and on Long Island in 1776. Made Colonel, 3d New Hampshire Regiment in November, 1776; took part in the battles of Trenton and Princeton; was wounded and especially distinguished at Saratoga; was Adjutant General of the Army from early in 1778 to 1781; Colonel, 1st New Hampshire Regiment, January 1, 1781, and in July took command of a regiment of light infantry.

While Officer of the Day at the siege of Yorktown, September 30, 1781, he was surprised while reconnoitering, and after surrendering, was inhumanly wounded, and died in a few days. He was an officer of great merit and of amiable character. He was six feet and two inches in height.

FORT LEVETT. Named in honor of Christopher Levett, who was born in the city of York, England. Baptised April 5, 1586. Family one of prominence. In 1618, King's Woodward of Somersetshire, from whose forests was drawn the timber for the British Navy, which forests it was found at that early date necessary to protect against trespassers. In 1623 he appeared as one of the captains of His Majesty's ships; May 5, 1623, the Council for New England voted him 6,000 acres of land, to be selected by him within the limits of its charter. He sailed from England in 1623 with fifty men, with the intention of building a fort and founding a city to be named

York. He reached the Isles of Shoals in the autumn of 1623 and after some stay at the mouth of the Piscataqua, proceeded to explore the coast to the eastward. After going as far east as the Sagadahoc, he returned to "Quack" (Portland Harbor) and set about erecting on an island at the mouth of the harbor a habitation fortified for protection against the Indians. Placing ten men in possession, Levett returned to England in 1624 where he found his venture had fallen into disfavor because of its being a monopoly. In 1625 he commanded a ship of three hundred and twenty tons in the expedition against Spain. He appears to have been in America again later for Winthrop records that when he cast anchor in Salem Harbor June 12, 1630, Captain Levett came aboard. It appears that he was at that time in command of a ship and shortly afterwards sailed for England, but died on the passage. The strong house which Captain Levett built was no doubt a fishing and trading post, and not of the nature of a fort. Its location has been the subject of some controversy. It is claimed by some that it was on Peaks Island, by others on Cushing Island, and by others on House Island (Fort Scammel). Among the latter is Hon. James P. Baxter, from whose publication, "Christopher Levett," the above data is compiled. House Island has continued to be up to a few years, a favored place for curing fish.



FORT AT NEW CASCO, BUILT BY COL REDKNAP, IN 1705.

NOTE. – The ground plan of this fort was found in the office of the Public Records, London, by James P. Baxter, in 1886.

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IMPROVEMENT

OF THE

MISSISSIPPI RIVER

BETWEEN ST. LOUIS AND CAIRO.

BY

WILLIAM P. WOOTEN,
1st Lieut., Corps of Engineers, U. S. A.

PRESS OF THE ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.
—1902—

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IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN ST. LOUIS AND CAIRO.

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William P. Wooten, 1st Lieut., Corps of Engineers, U. S. A.

IN 1872, the improvement of the Mississippi River, between the Missouri and Ohio Rivers was begun in accordance with the provisions of the River and Harbor Bill for that year, which carried an appropriation of $100,000 for beginning the work.

The Mississippi River, above the mouth of the Missouri, is a comparatively clear stream flowing in a fairly stable bed. The Missouri, however, comes in heavily laden with sediment and the whole character of the Missisipi below their juncture changes. The bed and banks are chiefly of alluvial deposits, and as a rule, are easily eroded, causing constant changes in the position of the principal current and consequently a constant shifting of the whole bed of the stream.

The low water discharge at St. Louis, about 16 miles below the mouth of the Missouri, is about 30,000 cubic feet per second, the ordinary flood discharge is about 750,000 and the maximum known discharge is about 1,200,000 the mean discharge being 225,000, of which the Missouri brings in somewhat over one-half.

The slope in the reach under consideration averages .44 of a foot per mile, but varies between one-half to double this amount. The river in its unimproved state varies from .5 to 1.5 miles in width and meanders from one side to the other in an unstable bed, between bluffs from 3 to 8 miles apart, for a distance of about 160 miles. Thence it flows for a short distance through a gorge and emerges at Commerce, Missouri, into the alluvial valley of the lower Mississippi.

The variation in level at St. Louis ranges between limits about 35 feet apart, ordinarily, but the highest known flood (in 1844), rose 42.5 feet above extreme low water.

The high water season is generally from March to July, low stages prevailing the remainder of the year.

From December 1st. to March 1st., navigation is usually suspended on account of ice reach or by increasing the length of the reach. A reduction of slope, by lowering the level of the upper end, is always a consequence rather than a cause of river improvement and is to be avoided as much as possible, as it necessitates a reduction in the depths above the improved portion. One result of the improvements under consideration in this paper has been the lowering of the low water level at St. Louis. Exactly how much this lowering has been, can not be determined from the insufficient data available but it is believed to be about 2.5 feet. The lengthening of the river as a means of reducing the slope, can, of course, be effected only to a very small degree and is touched upon chiefly to show the undesirability of shortening the stream in any way and to furnish an additional reason for preserving easy curves and avoiding cut-offs.

This leaves us then the element of width as the only one within the range of control by modifications of which the river may be induced to cut itself a deep channel. Contraction of excessive widths is then the easiest and most practiable method of securing the desired depths.

The second requirement, the judicious location of the improved channel, is best secured by following the natural tendencies of the river and endeavoring to hold the river in the course which it has worked out for itself rather than by attempting to force any violent change in its course. It is a well known fact that any great and sudden change made in the channel of a stream upsets its regimen for a long stretch above, and a considerable time must elapse before a condition of equilibrium is resumed. It is stated that the Mississippi River, above Kaskaskia, has not yet entirely accommodated itself to the conditions brought about by the Kaskaskia cut-off by which the channel was shortened 5 or 6 miles in 1881.

The objections to straightening the channel, a method which formerly had its advocates, have been stated already. The suggestion that the channel should be made to follow the bluff has in its favor only the fact that one side of the stream would be hard and unyielding and would therefore need no protection. To offset this advantage which is more apparent than real, we have the fact that as the bluffs are approximately straight this proposition meets with the same objections as the one just mentioned. Any considerable changes made in the location of the channel would also greatly disturb existing business relations. The advisability of following existing channels is thus in accordance with policy as well as with engineering considerations. The third requirement, stability in position, is essential to the establishment of facilities for trade. The necessity for the channel following a fixed line needs no demonstration. But this stability in position must be taken to refer not only to the axis of the current but also to the bars.

The positions of the bars in the natural river are constantly changing. The sand proceeds slowly down stream in waves. If, as the result of works of improvement, these reefs or bars can be made to remain in definite localities, if the bars can be fixed in position, then their improvement either by permanent works or dredging is a much easier problem and can be undertaken with the assurance that your bar will not elude your improvement work by moving down stream.

The fourth requirement, facility of approach to established landings, should really be considered as a part of the second requirement, i. e. the judicious location of the channel. This requirement is often in conflict with an easy solution of the problem from an engineering point of view but it is a requirement of considerable importance and must be given its full weight in deciding between different lines of improvement works for a given locality.

The fifth requirement, that changes of direction should be easy, is in the interest not only of stability but also of easy navigation. However, these changes of direction should not be too easy. A channel maintains its depth best along a curve, but if the curve is too flat the channel will not follow the concave bank throughout and the difficulties met with in the straight reaches are encountered. If, on the other hand, the curve be too sharp, erosion of the concave bank is greater, bank protection is more costly and navigation more difficult. The proper radius of curvature differs for different streams and must be separately determined for any given one. Thus a radius of from 5000 to 10000 yards might be proper for the Mississippi, while such a radius would be entirely too great for a smaller stream.

The sixth and last requirement, that the velocity shall be moderate, does not in the case *of the Mississippi call for any work* especially designed to meet it.

If the contraction works are kept to their proper dimensions the velocity will not be so *excessive as to impede navigation.*

The methods which have been followed on the Mississippi river between St. Louis an Cairo for meeting these requirements have been mainly contraction works and bank protectio

The object of contraction works is to so reduce the width of the river as to force it to scou out for itself a deeper channel in order to secure a cross section sufficient to carry its volum of discharge. The width to which the river was to be contracted was fixed at about 25 feet. Dikes or dams closing side chutes around islands or toeheads are included under tl head of contraction works as both their purpose and their result are to contract the waterwa

The bank protection was intended, of course, to protect the banks against erosion, the being two reasons why the erosion of the banks should be prevented: 1st, in order to hold tl channel in a fixed position by preserving the bank itself; and, 2d, in order to cut off as muc as possible the supply of bar forming material.

The chief question to be decided in each locality in which contraction works are put co cerns the line which the channel must be made to follow. In studying the works alread placed in the portion of the river under consideration, we find instances of both the right wa and the wrong way to place them. As is well known, whenever a river flows around a curv the channel is always in a fixed position, and we find that wherever contraction works hav been placed on the convex bank, and bank protection on the concave, good results have invar ably followed. Other considerations, more practical and less theoretical, but equally importan support the same method i. e. the considerations of ease of construction and of cost. Th convex side of the river, being less deep than the concave and having a less velocity of cu rent, contraction works are more easily constructed and more efficient in causing deposi than when placed on the concave side.

In straight reaches in need of contraction the works should, if practicable, be so placed to change the reach from a straight one to one having a succession of curves. When this h been done the results are as good as in the former case. But where the works are so place as to flatten out curves, converting them into almost straight reaches, or where straig reaches already in existence are preserved, the result has been a channel which is constant shifting in position and frequently insufficient in depth.

Another very important result of the river's following a series of curves instead of a straig reach is the permanence secured in the position of the bars. As bars will occur only at th crossings, their position is definitely known and if the works are properly designed they wi rarely interfere with the projected depth, and at such times as they do give trouble a littl dredging will give prompt and sure relief.

It follows then that the requirement of sufficient depth at all stages, as well as that of st bility of position, is best fulfilled by placing the contraction works so as to guide the chann as far as possible into a series of easy curves. Incidentally this also slightly increases th length which has been mentioned as a desirable end to be attained.

The use of ground sills has found no place in the scheme of improvement followed th far. The action of ground sills is to ultimately raise the level of the bottom in the pools an thus increase the slope in these places. As an increase of slope in one place necessitates dim inution in another, the final result is to make the slope more uniform. During the formatio of the deposits necessary to raise the river bottom the sills act as submerged dams and effe the same results. This system has been followed successfully with many European river especially with the Rhone, where the drop of over 4 feet in the low water level at L Mulatiere, due to previous improvements below has been, in a measure, regained. The us of such a system seems hardly necessary with the Mississippi as the slope is not very exces ive and the results obtained from contraction of the width and protection of the banks justif the expectations that the projected depth can be obtained by these means alone. Moreove the use of ground sills would involve great expense on account of the width of the river an the great depths of water in which they would have to be placed. Works of this nature i the reach under consideration being founded on an unstable bottom would also be quite vu nerable to attack by the violent floods which occur, as is seen from the damages caused t the stone dikes and dams at first constructed.

In beginning the work of improvement of the river, Gen. Simpson determined upon *amelioration of the worst* bars first and made his estimate apparently on the supposition *the removal of the bars* then in existance would bring about the projected depth at once evidently underestimated the effect which would be produced by the improvement of one locality on the river above and below. Bars act as submerged dams separating pools of slight slope, and the lowering of one of these dams lowers the water in the preceding pool, increases the slope at the preceding bar and aggravates such bad conditions as may be found there already or, in many cases, produces bad bars where the depth had previously been sufficient.

Bars lower down the river are also built up by the deposit of material scoured from the bar under improvement. Thus the improvement of one bar forces an extension of the works in both directions and to a degree which can hardly have been foreseen. Sufficient allowance for this was not made in the original estimate and later, in 1883, the estimate was more than doubled.

In the project of 1881 the order in which the work was to be done was changed and it was decided to proceed with the work uniformly down the river from St. Louis. From an engineering point of view the question as to whether the original improvement should have proceeded from St. Louis down the river or from Cairo up, is an open one, but at this time practical considerations due to the fact that most of the work which had been done was in the vicinity of St. Louis were undoubtedly sufficient to justify the order of work adopted.

TYPES OF CONSTRUCTION.

The contraction works first used in 1874 consisted of spur dikes, each dike being a riprap of stone built 8 feet above low water and superposed on a foundation or platform of brush from 2 to 5 feet in thickness and varying in width to suit the height of the dike, held in place by piles until loaded, an apron of brush about 2 feet thick also held in position by piles and stone having been previously laid below and alongside the dike, though not connected with it, to prevent the dike from being undermined by the fall of water over it. The dikes were 3 feet wide at the top and the stone took its natural slope. Where such a dike was constructed on an alluvial bank it was carried back 200 feet over the bank. The bank was further protected by a longitudinal dike 250 feet long, with cross dikes 100 feet long, running back on the shore at its ends.

Dams closing sloughs were similar in construction. The design was modified, in some instances, by constructing the dike of alternate layers of brush and stone instead of a mound of stone on one layer of brush and with this and other slight modifications was continued in use until about 1881.

It was intended to connect the channel ends of the cross dikes by a training wall as soon as deposits were made, and one was built at Horsetail Bar but was never fully completed.

Stone dikes thus constructed were found not to be so efficient in causing deposits as had been desired and expected; so, in 1879, a number of hurdles were interpolated between them to hasten the deposit of sediment. The results obtained were very satisfactory and in 1881, the old dikes having proved costly to build and difficult to maintain and not being very efficient, it was determined to rely entirely upon hurdles, and contraction works undertaken since then have been hurdles alone.

The hurdles built in 1879 consisted of a row of light piles about 5 feet apart, connected together by weaving or wattling willow poles between them and pushing willow brush vertically into the interstices of the wattling. The top of this brush projected about 8 feet above low water while the lower courses of the wattling could not be forced down lower than 8 feet below low water. The cost was about 80 cents per lineal foot. These hurdles were frail in design and were not expected to last more than one season. Where the water was too deep to drive these piles and construct the hurdles in position a curtain of woven willow poles and brush was constructed. The lower edge of this curtain was then anchored either to a horizontal mattress or directly to the bottom and the upper edge supported by buoys. Longitudinal walls built of hurdles were known as primary, and cross dikes as secondary hurdles. As the use of hurdles was continued the designs were modified and improved, and changes were made which rendered them stronger and more permanent, the present hurdle being finally evolved. The present hurdle consists of a row or parallel rows of three pile clumps spaced 8 to 12 feet apart, the piles in each clump being drawn together and fastened at the top by a wire cable. Where the water is shoal and the current weak a single row of clumps is usually sufficient; under other circumstances the clumps are staggered in such a way that longitudinal stringers can be placed between the rows to transmit and distribute strains. One pile in each clump in the upstream row reaches the level of the 25 foot stage, the other piles in the first and second rows being 5 feet lower, while the remaining rows are 5 lower still.

The foundation mattress varies in width from 75 to 100 feet, about 35 feet forming an apron on the upstream side. Extra stone is always thrown around the feet of the piles to prevent scour where the mattress is broken by driving the pile through it.

The channel ends of the hurdle are protected by T heads of two rows of clumps projecting 50 feet above and 100 feet below the hurdle, the foundation being a mattress 120 feet by 300 feet. Buttresses of stone are placed at the channel ends, and the shore ends are protected by revetments for about 300 feet; drift collected above the hurdles is sunk by laying on top of it a sort of mattress of brush as evenly and rapidly as possible and then weighting the whole with stone. A curtain of brush is constructed and supported by the piling where no drift occurs. As soon as the hurdles caused a deposit reaching about the 17 foot stage, willows began to grow and by checking the velocity of high water caused further deposits to be made. The artificial banks thus formed may be protected as described for natural banks. The distances apart of these hurdles is from 1000 to 1500 feet. Their cost ranges from $10 to $35 per lineal foot.

The original plan adopted for bank protection was to excavate, where necessary, a trench to the depth of 8 feet below lowest water, and fill it with brush in crossed courses, the tops reaching outward as far as practicable to form a mattress to protect the base from scour. On the brush, riprap is placed until it appears at mean low water, assumed 5 feet 6 inches above lowest low water where it formed the base of the stone revetted slope, with an inclination of 1 vertical to 2 horizontal. This work has served its purpose well and is still in good condition, probably owing its stability to the fact that it was placed in comparatively shallow water. From 1875 to 1881, protection under water, or subaqueous protection, was given by rafts or mattresses of brush from 40 to 70 feet wide. These mattresses were effective except in deep water with strong current where their outstream edge was undermined.

In 1881 was adopted the form which, with modifications as to details, has remained in use until recently. It consists of a woven mattress of cotton wood, or preferably, willow brush. It has but one thickness of brush woven upon poles, is thin and flexible and sufficient strength during construction is secured by ample fastenings of nails, spikes, wire and cable, all of iron. Their width must be sufficient to reach to the foot of the eroding slope and a standard width of 120 feet is adopted as ordinarily sufficient. They are, as a rule, made continuous for each locality, lengths of from 5000 to 10,000 feet having been made and sunk. They are sunk and held in place by stone, and furnish permanent protection to underwater slopes, the few known failures having been due to the undercutting of the water which subsequently deepened. The average cost of brush mattresses 125 feet wide is $6.00 per lineal foot.

During the past four years a number of lumber mattresses have been built. The lumber used is the commonest culls 4 to 6 inches wide, 1 inch thick, and not less than 12 feet long. The mattress is formed by weaving the plank over and under plank laid longitudinally about 3 feet 9 inches between centers, like large split basket work. These mattresses require much less bulk of timber and of stone than the brush mattresses, can be built about twice as fast and cost only about $3.75 per lineal foot. Their only disadvantage so far as known consists in their breaking up worse when piles are driven through them.

Protection above water is given by grading the bank to its natural slope and covering with riprap. The paving is usually done as far as the river has graded its own bank and resumed the following season after the high water has extended the grade further up the bank. When necessary to grade the bank by artificial means it is done by the hydraulic method or by means of shovels, etc.

In addition to the permanent works of improvement, each year a certain amount of work is done to afford temporary relief to navigation or to hasten the results of the regulation works. The devices employed for this purpose include dredging and the use of temporary jetties to produce scour. The plant includes three suction dredges, a jet dredge, a tow and dredge boat, two other tow boats arranged to use their wheels in washing channels through bars and panels for about 10,000 feet of portable jetty. Several types of portable jetties or temporary dikes have been used. The type most favored is constructed by driving a row of piles along the line selected and connecting them by a stringer which serves as a support for the upper ends of corrugated sheet steel panels, whose lower end rests on the bottom of the river.

Each panel is 10 feet wide and from 10 to 20 feet long, depending on the depth where it is to be used. To prevent scour taking place under the panels, a small fascine mattress 8 to 10 feet wide is fastened to the lower edge of the panel and sunk with riprap. At the end of the low water season the panels and piles are taken up and preserved for future work.

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RUSSIAN PROVISIONAL FORTIFICATIONS

A TRANSLATION OF A SERIES OF STUDIES ON PROVISIONAL FORTIFICATIONS BY RUSSIAN OFFICERS

From the "Mitteilungen über Gegenstände des Artillerie und Geniewesens." Series of 1904, Parts I, II, III

Translated by
FIRST LIEUTENANT ELLIOTT J. DENT
Corps of Engineers, U. S. Army

and
FIRST LIEUTENANT GEORGE R. SPALDING
Corps of Engineers, U. S. Army

WASHINGTON BARRACKS, D. C.,
PRESS OF THE ENGINEER SCHOOL,
1905.

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TRANSLATOR'S NOTE.

The following series of articles is taken from the "Mitteilungen über Gegenstände des Artillerie und Geniewesens" for the year 1904. As stated in the introduction, they are translations from the Russian and they have now undergone a second translation. This double translation accounts for many of the discrepancies which appear from time to time and to which attention is called in foot notes. In all cases when a liberal translation will not give what the translator believes to have been intended, the translation is given in the body of the article and the supposed meaning is given as a foot note.

A general discussion of these works appeared in the 7th number of the Mitteilungen for 1904, and no attempt has been made to discuss the general principles involved, but attention is invited from time to time to what appears to be defects in detail. It will be noted that none of these defects occur in all the projects.

It will be interesting to compare the theoretical forts shown in this paper with the practical working forms in use in the present war. There is a marked similarity between the fourth of these plans and the fort shown in the frontispiece, but no field guns are shown in this illustration, which is more nearly in accord with the theories of the English School.

The extensive use of railroad iron in all of the plans will of course be impossible in the present war, but no doubt it can be replaced by timber, when this is available.

E. J. D.

PROVISIONAL FORTIFICATIONS ACCORDING TO RUSSIAN PLANS.

In the fourth number of the "Mitteilungen" for the year 1902 appeared a translation from the Russian of a discussion on the proper strength of parapet and shelters in provisional and semi-permanent fortifications.

The original paper written by N. Bujinicki, Colonel of Russian Engineers, appeared in No. 11, of the "Inzenernij Journal" for the year 1901, under the title of "Plans for Provisional Land and Sea-Coast Fortifications."

In this paper the author confined himself to a mere theoretical discussion of the question and promised to follow the discussion with practical examples designed accordingly.

The series of these Examples which was appearing in the unofficial section of several numbers of the Inzenernij Journal is now closed. Although these articles bore no official character, still they give an idea of the opinions held in Russian circles concerning provisional fortifications. These articles usually originate in the Engineer Department and are criticised by a special commission, the approved opinions being published and prizes awarded.

We publish some of these examples for the information of our readers.

EXAMPLE I.

A provisional fort for three companies of infantry, eight field guns and four machine guns.

By J. BAZANOW.

[Mitteilungen, Jahrgang, 1904, Erstes Heft.]

Translated from the German by
FIRST LIEUTENANT GEORGE R. SPALDING,
Corps of Engineers, U. S. Army

(PLATE I.)

The plans are based upon the following assumptions:

The work is one link in a chain of similar fortifications. Each work must be so designed that it may be defended as soon as possible and that it may later be completed without interfering with its continuous defense. The parapet must be capable of withstanding the fire of field and siege guns.

Two companies of the garrison will be quartered in the interior of the work, the remaining company near the counter-storming guns and in the bomb-proof in the forward redan.

In the plans the following points were considered:

A. The trace of the work (Fig. 3), the distribution of the garrison, and the profile of the faces and flanks (Profile CC) should all be selected with a view to developing as powerful a frontal fire as possible, and a sufficiently strong flanking fire. The Lunette form, with a salient angle of 125° and shoulder angles of 140° fulfils these requirements. The length of each face is 416 feet, each flank 172 feet and the gorge 900 feet, making the entire perimeter 2,080 feet, which allows one man to each 6½ feet. (See below.)

The distribution along the firing line is as follows:

*a. Infantry.**

In the capital redan,	1 section	1 section.
Along each face,	2 sections	4 sections.
Along each flank,	1 section	2 sections.
Along the gorge, one section on each side of the gorge redan,		2 sections.
In the gorge redan,		1 section.
Reserve, whose fighting position is on the parados,		2 sections.
		12 sections.

b. Artillery.

One field gun (counter-storming gun, Gegen-sturm-geschütz) on either side of the capital in the salient and one in each shoulder,	total 4 guns.
Two field guns at each end of the gorge,	4 guns.
Two machine guns beyond each flank for enfilading the outer ditch in front of the capital redan,	4 guns.

In addition a gun platform is erected on each side of the gorge redan to make possible the party use of the guns in reverse fire.

B. The salient angle (Fig. 3) being the most important point in the defense of the work, must be the most strongly fortified. The garrison of the capital redan must be protected against high angle fire. For this last purpose there should be constructed under the face of the redan, shelter for 50 men. The walls of this shelter (Profile DD) are of timber, the roof, a double layer of railroad iron and a covering of earth 10.4 feet thick. In this bomb-proof are two ammunition recesses.

The capital redan is surrounded by two ditches, an inner and outer. The first will be covered by frontal fire from the redan and faces and enfilade fire from the shoulders. The second, on the other hand, will be raked by the two machine guns, near the shoulders and beyond the flanks. Both ditches are obstructed by wire entanglements and abatis. The width of the wire entanglement is 21 feet in the outer ditch and 38½ feet in the inner.

C. The defense of the ditches should be chiefly made by a flanking fire as this brings less work upon the garrison. The ditches of the faces and gorge are fired upon from the redans.

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*The number of feet of firing line per man in the different parts of the work is as follows: Along the faces 4.16 feet, along the flanks 3.44 feet, along the gorge 9.00 feet.—Translator.

D. Artificial obstacles (horizontal and vertical) should be made as wide as possible. With this idea in mind the main ditch was made 28 feet wide at the bottom so that it was possible to lay out in it a wire entanglement 24.5 feet wide, there being still a space of 3¼ feet for the workmen. The ditch is 14 feet deep and made difficult to surmount by scaling ladders.

E. As a large field of fire must be given the counter-storming guns (field guns), they must be advanced in position as much as possible. In accordance with this requirement the field guns, with the exception of the four pieces for raking the intervals, should be placed in the salients—*i. e.*, near the capital and in the shoulders. The protection of the guns in the shoulders is secured by shelters lying near the ramps and connected to the shelters for the men. (Fig. 3 and Profile FF.)

F. Bomb-proofs for the shelter of the garrison are as far as possible made capable of withstanding the fire of 21 cm. (8-inch) mortars and 15 cm. (6-inch) howitzers.

The bomb-proof barrack in the interior of the work (Fig. 3 and Profile EE) is intended for two companies lying down. It is built of logs with a roofing of a double layer of railroad iron and earth. The panel widths of the log walls are from 8 feet to 10½ feet. The thickness of earth above the layer of iron is from 6½ to 7 feet.*

The third company of the garrison is sheltered in the bomb-proofs near the gun platforms, 1½ sections (half lying, half sitting) are on each flank near the ammunition magazines, the machine guns, and the field guns in the shoulders. The remaining section (lying down) is in the bomb-proof of the capital redan, lying.

G. Inside of the work there should be a position which commands the parade and firing lines, under the protection of which the reserve may be formed to oppose the hostile occupation of any part of the work. This position is above the bomb-proof barrack.

H. The firing platforms of the guns used for flanking the intervals should be protected and so situated that the guns may seek the protection of a bomb-proof when not in use. For this reason the most favorable position seems to be the end of the gorge since in a position on the flanks outside of the work insufficient protection would be afforded. On the other hand, though they would be well protected if placed in the gorge redan, from such a position the foreground of the neighboring works could not be fired upon unless the redan were detached. This solution would entail more labor, make the work too deep, furnish poorer protection and complicate the supply of ammunition.

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*This is the thickness of earth above the double row of fascines mentioned below. The total thickness of earth and fascines is shown in Profile EE.—Translator.

The following refers to requirements of the "second grade"—*i. e.*, details which though they appear to be desirable, are not essential to the existence of the work:

(*a*) The counter-storming guns must have mobility within the work. This is necessary in the exigency of a gun-platform's being destroyed. To answer this demand two gun positions are established near the entrances, where the guns have partial protection from the fire of the enemy. In addition, two guns may be placed on either side of the gorge redan by cutting the platform in the parapet.

(*b*) The distribution of ammunition should be as simple and reliable as possible. For this purpose additional ammunition recesses should be built near the guns. Their distance from each other should be 14 feet, this is reduced to 9 feet in the magazines to simplify construction. Usually the recess is 4½ feet long, 3½ feet high and 3½ feet wide, and will hold 60 cartridges or projectiles.

In estimating the number of recesses a reserve should be allowed in the event of damage.

(*c*) For the machine guns a well sheltered, accessible position must be selected which favors the most extensive use of rapid fire.

In the foregoing example they are placed near the flanks so that they can enfilade the ditches. These platforms are 7.5 feet square. When not in use the guns are under cover of a "lean-to" in front of the bomb-proof near them. In the bomb-proof are recesses for machine gun and small arms ammunition.

(*d*) In the interior of the work there must be left sufficient free space.

(*e*) The slopes of the excavations and embankments must be such as to resist atmospheric influences and shells. All slopes having a length up to 16 feet should be less than one-half and the outer slopes of the magazines must be less than two-thirds.

(*f*) A berm, one meter wide, is left between the outer ditch and the parapet in order to catch the earth thrown from the exterior slope by the explosion of shells, before it falls into the ditch.

(*g*) The parapet must withstand the effect of 21 cm. (8-inch) mortars and 15 cm. (6-inch) howitzers. Their thickness is arrived at from the following formula:

$E=S+\frac{d}{2}+H$, in which E is the thickness of of the parapet, S the penetration of a shell in falling, $\frac{d}{2}$ the radius of the crater, H the height of the the parapet which is here considered 10.5 feet. We have therefore by substitution, $E+18.0+\frac{11.7}{2}+10.5=34.4$ feet. For embankments in the interior, as for traverses which can easily be repaired $E=10.5+13.8=24.3$ feet, is permissible.

(*h*) The roofing must be sufficient to withstand 21 cm. (8-inch) mortars and 15 cm. (6-inch) howitzers. There are placed in all covers two layers of fascines laid crosswise over each other, since experience has shown that intermediate layers placed at the depth of, or slightly below, the point at which a penetrating shell will explode are of especial value. The fascines are 12 feet long and 9 inches in diameter. The depth of the earth above these layers is that of the penetration of 21 cm. (8-inch) mortar shells or 6½ feet. For the sake of economy the roof near the gorge consists of a layer of rails (Profile EE), a double layer of logs and 13 feet of earth covering, without fascines.

(*i*) The entrance to the bomb-proofs must be protected.

For this purpose an inclined iron roof (entrance screen) is provided. These screens, under which the guns are placed when not in use, rest upon log walls, 3 feet, 3 inches high, (Profiles FF, GG and HH). In order that shells will not penetrate it, the inclination of the screen to the horizontal plane should not be less than from 10° to 15°.

(*k*) In a three-company work, two entrances are necessary. In this case these are at the ends of the gorge redan and are 28 feet wide. They are protected partly by enfilade fire from the gorge casemate and partly by frontal fire from the gorge redan.

(*l*) In order to properly drain the interior of the work, a drainage ditch is laid from the work to the outer ditch. The elevation of this ditch is as follows:

At the salients 0.0 feet, in the parade by the bomb-proof barrack, 7 feet; at the entrance, 10½ feet; in the gorge ditch, 10½ feet; in the outer ditch, 14 feet. Drainage of bomb-proofs is secured by the use of drain pipe or cess-pools.

To provide storage for the ammunition and to expedite its distribution there are provided in the work two magazines, each with 18 recesses (Fig. 2 and 3). The recesses are formed of frames capable of being used as mine entrances and are of the dimensions heretofore given.

The parapet at the flanks is run out into a glacis-like slope so that fire from the flanks can be brought upon the obstacles in the ditch.

There are five exits from the bomb-proof barrack, two toward the faces and three toward the gorge.

In all bomb-proofs the sides toward the enemy are protected by stone ballast. (Profile FF.)

For the ventilation of all the bomb-proofs, zinc or galvanized iron ventilator pipes are used. The diameter of the pipe should be from six to nine inches. In addition to these, venilation galleries are provided in the bomb-proof barrack. These are formed by covering the projecting ends of the logs with plank.

As it is desired that the work should be at all times defensible while being developed into a half-permanent or permanent fortification no shelters were provided under the banquette.

Storage room for ammunition was planned according to the following allowances:

No. of pieces	For each gun or rifle.	Total.	Per Box.	Total boxes for two Mag.	Total boxes for each Mag.
8 Field Guns.	300 Rounds.	2,400 Rounds.	5 Projectiles. 5 Cartridges.	480 boxes. 480 boxes.	240 240
4 Machine Guns.	8 boxes of Am.	32 Boxes.		32 boxes.	16
600 Rifles	500 Rounds.	300,000 Rounds.	900 Rounds.	334 boxes.	167

In the explanation of the plan a careful calculation of the necessary amount of labor and material and a statement of cost was given.

From these several calculations we give the results only of those which throw light on the size of the work, the amount of earth moving required, and the transportation of the heaviest materials.

The excavation is reckoned at 110,000 cubic yards, the embankment at 108,700 cubic yards. In spite of the enormous amount of earth moved there is still a considerable excess of excavation.

The following materials are necessary: 3,528 logs, 21 feet long by 10 inches in diameter, being a total of 74,088 running feet. 7,761 rails, at a total weight of 1,525 long tons, or over 150 wagon loads, at 10 tons to the load. 1,014 plank, 2½″×9″×21′. 24.5 long tons of iron nails. 555 stakes, 1¾ inches in diameter and 21 feet long. 36,750 cubic feet of brush for the construction of 4,000 fascines, 9 inches in diameter by 12 feet long.

The number of workmen was calculated on the basis of completing the work in thirty days. The daily total is as follows:

For excavation,	620 earth workers.
For levelling,	82 earth workers.
For revetments,	60 earth workers.
For transporting,	84 carriers.
	12 carpenters.
total,	860 workers.

For framing and building the shelters, 310 men per day, of which number 103 should be carpenters, making a grand total of 1,170 men per day.

The total weight of the building material to be transported is calculated at 81,835 long tons, (!) so that if the haul be reckoned at 3.1 miles, there will be necessary for each 16.36 tons, 7.97 wagons, and each wagon must make 4.18 trips per day.

The total cost of the work, material, etc., reaches in round numbers $362,712. (!)

(Signed) MAJOR v. DEBNO-GOLOGÓRSKI.

NOTE.—Throughout this work the interior slope has been given an inclination of 1 : 1. Considering the elaborate character of the fort it would be much better to have revetted this slope and given it a greater inclination.

The magazines (Figs. 2 & 3 and Profiles BB & HH) consist of a central gallery with niches on either side. It is doubtful if this arrangement would serve to localize the effect of an explosion in some part of the magazine and unless this end is accomplished there seems to be no object in such a form. The size of the niches, 3½ x 3½ x 4½ feet makes it unnecessarily difficult to handle heavy boxes of ammunition. The magazine shown in Example IV is much more compact and convenient.

No latrines have been provided.—Translator.

EXAMPLE II.

A provisional field fort for two companies of infantry, six field guns and two machine guns.

By P. UNTERBERGER,
Russian Military Engineers.

[Mitteilungen, Jahrgang, 1904, Zweites Heft.]

Translated from the German by
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(PLATE II.)

The plans are based on the following assumptions:

1. The work, which is designed as a point of support of a defensive line, must, in the fullest sense of the word, be suited for self defense.

2. It must be able to assist with its fire the neighboring works and the adjacent intervals.

3. It must protect its entire garrison against direct fire and must have bomb-proofs for at least half the garrison.

The work is of a strictly provisional character, that is, after its completion it can not be strengthened to the half-permanent class.

On the drawing, Plate II, the following will be noted:

1. The garrison, consisting of 400 men, is subdivided as follows:

a Inner reserve, 100 men.

b Sixty-four men on each face, total for the faces 128. Allowing 3½ feet per man, each face must be 224 feet in length.

c Fifty men on each flank, total for the flanks 100. The above rule gives 175 feet as the length of each flank.

d The remainder, 72 men, for the gorge. Allowing one man for every seven feet of firing line, we obtain 504 feet as the length of the gorge.

2. The armament of the work is distributed as follows:

Four field guns are assigned to the defense of the interval and are placed in the gorge redan.

The remaining field guns are placed in the salient angle.

The two machine guns are used in their capacity as rapid firing guns to defend the ditch, and are placed behind the earthmask in front of the faces.

The two field guns used to oppose the assault (Gegensturm-geschütze) might be placed separately in the shoulder angles, but such an arrangement would increase the amount of earth-work, by requiring two gun platforms instead of one, and would also split up the artillery fire, which should be avoided.

In general, the ditches of the faces and flanks may be secured in three ways:

1. By counter-scarp galleries.
2. By a redan in the salient angle.
3. By an open or covered flanking work which is placed in the end of or in prolongation of the ditch.

The first method is now used in permanent fortifications, as it is the surest. It would, however, rarely be used in provisional works, on account of the great difficulty in constructing a safe communication with the interior work. An open passageway across the ditch is insufficient. A covered passage, similar to a mining gallery would be very hard to construct. In order to protect it against high angle fire, its roof must lie at least 14 feet below the bottom of the ditch, or in the present instance, 28 feet below the plane of site. In the problem given the ground-water level was assumed at a depth of 23 feet and would not permit such a deep construction.

Of the two remaining methods, number three was chosen on the following grounds:

a The earthmask, which is built as part of the outer parapet, serves to cover both the machine guns which command the face ditches, and the rifle galleries in the flank ditches. By this method it is possible to get along with only two outer works whereas the second method requires three.*

b By the second method the firing line of the faces is broken and consequently shortened, to the prejudice of the frontal defense.

c By the adopted method part of the face ditches are secured by cross-fire, a result which could not have been attained by the second method.

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*A redan at the salient angle to flank the face ditches, and an outwork of some character for each of the flank ditches.—Translator.

d Underground passages lead to the galleries in the flank ditches. The third method makes it possible to construct them properly as they are protected by the thick parapet of the earthmask while their floors are only 14 feet below the plane of site.

Since the outer parapet would mask a portion of the outer ditch in case of its seizure by the enemy, the flank portion of this ditch is covered by infantry fire from the projection of the outer parapet at the end of the gorge. In order to sweep the ditch in question from its very beginning, the exterior slope of this portion of the parapet is sloped off like a glacis, with the foot of the opposite counter-scarp as a directrix. By this, it is true, the exterior slope becomes a warped surface of difficult construction, but by it the dead space is removed up to the flanking ditch. The latter is covered by fire from the galleries in the shoulder angles.*

The outer parapet serves a double purpose. It forms a connection between the machine gun recesses and the interior work, and at the same time provides for an outer tier of infantry fire. The gorge ditch is covered by the portion of the redan perpendicular to the gorge. (Profile KK.) The outer ditch of the redan is shallow, but the obstacle in it makes it as formable as the full size ditch.

The gorge redan serves also to cover the interval between the neighboring forts, which are separated from each other by distances of 3,000 to 4,500 yards. With this end in view it is carried back far enough to sweep the foreground of these works, at least to within 1,000 yards of the works themselves. On this account all siege-approaches directed against neighboring works, must be carried on under the fire of this one. The height of the parapet of the redan is taken as seven feet, in order to command the entire gorge and to permit of the construction of the gorge bomb-proofs in its equally high traverses. Between these traverses the redan is open to the inner work, but it retains the general character of an inclosure. The inner ditch of the gorge redan is similar to the gorge ditch.

A part of the inner portion of the redan is deepened to 14 feet (Profile FF), in order to obtain the earth necessary for the parapet and to make it possible to construct the bomb-proofs.

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*The elements of this surface are apparently taken parallel to *a* - *b* (Plan). The point *c* (Profile DD) marks the point where the foot of the counter-scarp of the flank ditch intersects the plane of the profile. This point can not be seen by a man standing in the plane of the profile, and this portion of the ditch is invisible except to men stationed very near *a* (Plan). It would seem better to make these elements parallel to the line DD, when the profile would be modified as shown by the broken line. —Translator.

On each side of the redan is an entrance to the work. The entrances are covered by the breast-work lying in front of them and connected with the traverses (Profile MM). Their depth is seven feet, the same as that of the parade.

The parade is excavated to this depth for the following reasons:

a To better secure the interior of the work against direct fire.

b To obtain the earth necessary for the bomb-proof roof.

c In order that the bomb-proof roof, whose height is 21 feet above the parade, should not project above the top of the parapet, whose crest is 14 feet above the plane of site.

To increase the security against assault, shallow ditches 42 feet wide and 2½ feet deep, are placed in front of the following portions of the work:

a In front of the salient angle, the most certain point of attack. Swept by fire from the faces. (Profile FF.)

b In front of the gorge redan, to secure it and the adjacent entrances against surprise. Swept by the withdrawn portion of the gorge parapet. (Profile OO.)

c On the earth masks, which serve as a cover for the ditch galleries. (Profile EE.)

The construction of the shallow ditch on the earth mask is due to the position of the latter at the shoulder angle, where the defense is, all things considered, weak. The strength of this obstacle is further increased by its being commanded by both tiers of fire. Thanks to this arrangement, an assailant advancing against the projecting mask, is forced to surmount, first the outer ditch swept by machine gun fire, and then the shallow ditch swept by two tiers of infantry fire.

The obstacle in the main ditch consists of a wire entanglement covering its entire width. On account of the insignificant breadth of the gorge ditch, an abatis is constructed on its bottom and counterscarp.

In the shallow ditch either form of obstacle may be used, depending upon the supply of posts and the rapidity with which the entanglement can be placed. In the plan, an entanglement is shown and in the profile an abatis.

In the work are the following bomb-proofs:

1. In the inner parade is an independent bomb-proof for a company. The front part of its mask joins on to the parapet of the faces and thus serves at the same time as a parados for the guns in the salient angle. By this arrangement the bomb-proof is best protected from direct fire, and the parapet, which in part lies just in front of, and in

part is joined to the mask, increases the strength of the latter by the thickness of the parapet. This arrangement also affords the greatest amount of open space in the interior of the work. (Profiles FF, GG, HH and Fig. 5.)

2. At the shoulder angles are rifle galleries to enfilade the flank ditches. These are connected with the machine gun recesses by covered passages. (Profiles AA, EE, II and Fig. 2.)

3. Finally there are bomb-proofs in the traverses of the gorge redan which serve to cover the ammunition for the field guns in the redan. Each traverse has a recess for one field gun. (Profiles BB, LL and Fig. 1.)

The roof of the bomb-proof consists of two rows ot rails ana a covering of earth. According to Déguis, its thickness may be computed by the following formula: $b = \frac{\sqrt{\frac{c}{N\,a}} - b'}{K} \times 7$ in which,

$b =$ the depth of earth between the point of explosion of a shell and the upper surface of the rails, necessary to protect the latter.

$c =$ the charge of a 21 cm. (8-inch) mortar shell. (50 lbs., gun cotton.)

$N =$ a coefficient for iron and steel, approximately 15.

$b' =$ the depth of the iron roof. For two rows of rails $b' = 6$ inches.

$k'' =$ a coefficient for earth, approximately 0.5.

$a =$ the strength of the portion of the metal roof included in the horizontal projection of a falling shell. Assuming the angle of fall of an 8-inch shell as 50 degrees, its length as 36 inches, the horizontal projection becomes, $36'' \times \cos 50° + 8'' \times \sin 50° = 28''.96$. The width of the bottom of a rail is four inches, and it follows that seven rails will come within the above projection. When two rows are used, the upper row with flange down in the intervals of the lower row (Fig. 5, Plate I), 13 rails may be considered. The strength of one rail is equivalent to one-half inch of earth and the total strength of the rail roof is therefore equivalent to $6''.5$.

Interpolating these figures in the above formula, we obtain,

$$b = \frac{\sqrt{\frac{50}{15 \times 6.5}} - \frac{1}{2}}{\frac{1}{2}} \times 7 = 3.08$$

Adding to this 10½ feet, the perpendicular penetration of an 8-inch shell, we obtain 14 feet as the necessary depth of earth.*

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*First Lieutenant Bujnicki gives 6.09 to 6.37 feet as the perpendicular penetration of the 8-inch shell in uncompacted earth of mixed composition.

The bomb-proof provides cover for one-half company lying and one-half sitting, with compartments for hospital, work shop, kitchen, company commanders and other officers.

Its size is determined as follows:

1. For each man lying, a space of 2½x6 feet is required.
2. For a man sitting, 2½x2½ feet.
3. For a subaltern, 49 square feet.
4. For a company commander, 147 square feet.
5. For the hospital, 147 square feet.
6. For the kitchens, 294 square feet.

As a result of recent experiments, and in order to better resist the action of projectiles, the bomb-proof is divided into cells whose floor space must not exceed 49 square feet.

The cells are built 6x7½ feet, and each cell will therefore accomodate three men lying down. For half a company lying down, 34 cells are provided.

Each cell will accomodate six men sitting on two bunks, with a passage 2½ feet wide between. For the half company sitting 16 cells are provided.

The location of the cells is as follows: (Fig. 5.)

The hospital is in the back part in order to give the wounded the necessary quiet.

The kitchens are also in the back.

Since the men sitting up are more nearly ready to go into a fight, they are placed near the outlet. While these are leaving the bomb-proof the remainder of the company can be preparing to leave it also.

Four cells near the outlet are assigned to the company lieutenants in order that they may leave the shelter ahead of the men and have the movement in hand from the start, thus preventing disorder and blocking.

The room for the company commander is in the back part, since he does not have to leave so quickly. In case the work is threatened, the portion of the garrison that is awake, falls at once under the command of the company commander on duty, unless a commander of the fort has been named, and he thus becomes the commander of the outer half of the company off duty.

In compliance with the above conditions, the sitting men are in the first row, nearest the gorge. This row has 18 cells, sixteen for the men and two for the officers. The second and third rows are for the men lying down and there is a five foot passage between them. Behind the third row is a passage four feet wide. A wing projects backward from the center of the bomb-proof, by which means space is obtained for the hospital, kitchen, and the company commanders' quarters. The cells are divided into six groups of nine cells each, by five foot passages, perpendicular to the length of the bomb-proof. The officers' cells are on the middle passage.

The cross passages in the wings are connected with the passage along the rear wall, so that there results a continuous gallery connected with the outer air by the cross passages and by several ventilator shafts through the roof.

Behind the end and back walls of the bomb-proof, a gallery is built two feet wide at the top and three and a half feet wide at the bottom. Its outer wall consists of a line of sloping posts three inches in diameter, supported at the upper end against the overhanging ceiling of the bomb-proof. Openings are made into this gallery near its top and bottom, to allow the circulation of hot and cold air. In this manner natural ventilation is obtained, which is increased by the ventilator shafts placed at intervals through the roof.

Near this gallery for natural ventilation, arrangement is made for setting up three "Dienenthal" fans for mechanical ventilation. (Fig. 5.)

As places to lie down, three bunks are built in each cell. One of these bunks is hinged to the wall and the middle bunk may be folded against the side one and the two folded against the wall. The other bunk is fixed.

This arrangement is carried out in all cells, so that by spreading out all three bunks, any cell may be used for three men sleeping, or by folding up the center bunk, any cell may be used for six men sitting. If all the bunks are extended, the bomb-proof will hold one-third the garrison lying down. If all the middle bunks are folded up it will hold three-fourths of the garrison sitting. Bunks are placed in the officers' cells also.

The outlets of the passages are shielded with rail splinter-proofs. (Fig. 3.)

In front of the galleries in the flank ditches is a depression which is connected with the ditch by a ramp of 1:3 and whose sole is seven feet below the bottom of the ditch. (Profile EE.)

The ditch gallery has two stories. (Profiles AA, EE and Fig. 2.)

In the upper story is the rifle gallery flanking the ditch. In the lower is a rifle gallery which flanks the first and removes the dead space in front of it. There is an outlet into the depression.

In addition to the rifle gallery, the upper story contains:

a The passage connecting the upper story with the machine gun recess. (Fig. 2.)

b The bomb-proof for the detail assigned to the flanking gallery. Allowing one man for each 2⅓ feet in the width of the ditch, this detail will consist of nine men.

c Two cells with stairs, one of which leads to the lower story and the other to the outlet to the ditch. (1 and 1′ Fig. 2.)

The outer wall of the lower gallery is carried up to the same height as that of the upper gallery, so that the lower gallery has a minimum earth covering of seven feet. (Profile AA.) In order to increase the strength of this outer wall, the partition wall is carried up to the same height, the logs above the ceiling of the lower gallery being successively shortened.

The outlet from the lower story to the ditch is closed with a plank door, both sides of which are covered with sheet iron. The door has two, and the lower story, four loop holes.

The outer wall of the upper story reaches, like the partition wall, to the bottom of the depression. (Profiles AA and EE.)

For both rifle galleries, cartridge shelves are placed in the passages leading to the inner work. At the end of these passages are bomb-proofs, which, as above stated, serve as recesses for the machine guns and ammunition, and for the gun detachments. (Profile II.) The machine guns are placed under the splinter-proofs in front of the entrances.

The floor of the upper story of the flanking galleries and their bomb-proofs, is 14 feet, the ceiling 7 feet, below the plane of site. Since the earth mask is 7 feet high this gives a total cover of 14 feet as required by Déguis' formula.

The bomb-proofs in the gorge serve to cover ammunition, the splinter-proofs in front of them cover one field gun each. The remaining two field guns of the gorge, and the two in the salient angle, are placed under the spliner-proofs in front of the entrances to the main bomb-proof.

The rifle ammunition of the garrison is stored in the gallery surrounding the main bomb-proof.

The back walls of all bomb-proofs are surrounded by a filling of stone.

The splinter-proofs, which serve in part to cover the entrances and in part to protect the field guns, are all made of two rows of rails with their upper ends resting against a fascine. (Fig. 3.) Their lower ends are fastened in two ways (Fig. 5), according to whether the splinter-proof serves to cover an entrance only, or to cover an entrance and a field gun. In the former case the lower ends butt against a timber buried three or four feet in the ground, and are secured by another timber staked in place at the surface of the ground. In the latter case the lower end of the splinter-proof is supported by a crib-work 4 feet high. The lower ends butt against the outer wall of the crib while the inner wall supports them. They are fastened with a staked timber as above, and the crib is filled with earth.

On account of the height of the surrounding parapets, the splinter-proofs of the machine gun recesses are built in the same manner as those which cover entrances only.

For wire entanglements, both long (3½ feet) and short (2 feet) posts are necessary. The location of the entanglement is given above.

In conclusion there will be given an estimate of the material and labor necessary for its construction, and the approximate cost.

Total excavation ------------ 78,562 cubic yards,

Total fill ------------------ 79,375 cubic yards.

Making allowance for the increase in volume, this gives an excess of excavation.

Number of workmen:

Diggers, 1,000; 90 to 200 men to handle rails; and 100 carpenters. In round numbers 1,300 men.

Estimate of lumber:

a For the main bomb-proof. The length of wall in plan is 2,744 feet. For a height of 7 feet with 10½-inch diameter lumber, eight rows are required. Total, 21,952 running feet.

b For the gorge bomb-proofs, 2,856 running feet.

c For the machine gun recesses, 2,800 running feet.

d For the passages connecting the ditch galleries with the inner work, 2,240 running feet.

e For the ditch, galleries, etc.

For the upper story, 5,376

For the lower story, 2,688

Total 8,064 running feet.

Grand total of 10½-inch diameter timber for the entire work, 37,912 running feet.

Estimate of rails;

a For the ceilings, double layer, 854,000 feet.

b For the splinter-proofs, 18,340 feet.

Total, 103,740 feet.

Estimate of wire, 12,600 feet.

Total cost, $49,321.55

Time required, two and one-half weeks, in which one-half week has been allowed as a factor of safety.

The above estimate is based on the following assumed unit tasks for the different classes of work:

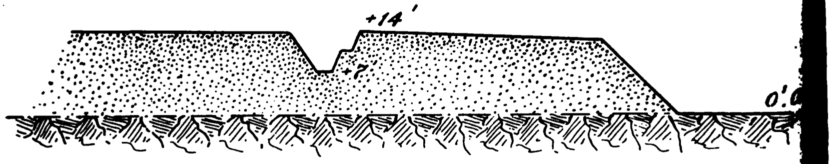
Excavation, 7.5 cubic yards per man per day, with men working at two pace intervals.

Each carpenter can frame and lay daily, 35 feet of 10½-inch timber.

DISCUSSION BY TRANSLATOR.

The outer parapet has a crest of 280 feet facing each flank, or spa for 112 rifles. This, in addition to the 50 men on the inner cres gives a total of 162, or more than one-third of the entire garrison o each flank. Since it would be necessary to reduce the depth of th fort as much as possible in order to lessen the chances of its bein hit, it would seem that the flanks of the one in question should b considerably shortened.

By placing the two field guns for frontal fire in the shoulder angle the necessity for a ramp between the main bomb-proof and the parape of the faces would be removed. This bomb-proof could then b placed about 45 feet to the front of its present position, and the dept of the work decreased by that amount. A considerable amount o earth-work would also be saved as the parapet of the faces would no form the mask of the bomb-proof. A complete trench would the be necessary along the faces. Profile CC, produced backwards, woul then become:



Bomb-proof latrines should also be provided. Three cells could b constructed at each end of the bomb-proof for the men, and one ne the hospital for the officers. By putting them outside of the ventilation gallery and giving them seperate ventilator shafts through th roof, their ventilation could be kept separate from that of th remainder of the bomb-proof.

Assuming that the guns in the gorge redan are to be located a shown, their protection is inadequate. The given profile affords n cover against projectiles which pass over the front of the fort an have an angle of fall greater than two degrees. This could be remedied by raising the traverses in the gorge of the redan by several feet and, at the same time building them closer to the gun platform The communication with the remainder of the work could be provided for without leaving the large open space shown between the two traverses. As now shown, the only function of these traverse is to provide magazines and gun recesses for the guns of the gor redan.

EXAMPLE III

A provisional field fort for two companies of infantry and eight field guns.

By [illegible] Austrian Military Engineer.

Mitteilungen, January, [illegible], [illegible] Heft.

Translated from the German by
FIRST LIEUTENANT ELLIOTT J. DENT
Corps of Engineers, U. S. Army.

PLATE II.

The plans are based upon the following assumptions:

The work is at an angle of a continuous line of defense. Height of interior crest, [illegible] feet. Bomb-proofs are designed for half the garrison. The ditch defense is principally from open enfilading [illegible]. Class of earth, medium.

The work must resist the action of the 8-inch (21 cm.) mortars of the German advance siege train. The most important data of these guns is: Caliber 8-inch (21 cm.); weight of the explosive shell in round numbers 220 lbs; length 4½ calibers (36-inch); bursting charge, 44 lbs guncotton; the angle of fall at a distance of 2,333 yards, approximately 40 degrees.

In explanation of the plans the following is given.

Since indestructible bomb-proofs can not be built in provisional works with the materials available in the field (wood, iron, and earth), the defense of the ditch of such works must be from open positions for rifles or for guns, placed behind the parapet. These are nearly [illegible] and [illegible] be occupied till the last moment. The ditch defense from open emplacements has the additional advantage when compared with closed galleries that it is safer and never breaks down at the critical moment.

The trace of the work is intimately connected with the method of ditch defense. In order to simplify the trace, the ditches of the faces and flanks are swept by fire from two flanking emplacements. The location

The strength of the fort is limited by its provisional character, and extensive use is made of obstacles in an effort to increase its defensive power as much as possible.

The obstacles consist, first, of a wire entanglement 21 feet wide in front of the work, and, second, of a vertical obstacle at the foot of the scarp, since the latter is much harder to cross than a horizontal one. The latter (Profile MN) consists of iron rails placed vertically 7 feet in the earth and held in place by means of stones. The rails are 4 feet apart and are interlaced with barbed-wire, so that there results a wire fence 14 feet high. Finally, since the orillons are important integral parts of the fort, an abatis is placed on the counterscarp of their ditches. In the gorge ditch there is an abatis only.

The following provisions have an added importance in view of the provisional character of the work and its limited security against the entrance of assaulting columns.

In the inner work is a keep which opposes the occupation of the parapet by the assailants until the arrival of the outer reserves, and which facilitates the recapture of the parapet. With this end in view, the keep is so arranged that it sweeps the inner work. The gorge is flanked from the keep, whose parapet is 10½ feet high, 3½ feet higher than that of the gorge.

The guns of the redan are protected by traverses which are part of the keep. In these traverses are niches for ammunition.

On both sides of the redan are symmetrically-placed entrances. They are secured by cross-fire from the adjacent traverses, and by the bomb-proof for a special guard. (Profile CD.)

The drainage of the fort is made easier by having the gorge ditch 3½ feet lower than the sole of the entrances. Moreover, in order to produce a flow of water, the inner ditch of the orillons slopes upward to the rear.

The estimate of work, material, time, and money for the annexed plans is given as follows:

The excavation is 59,182 cubic yards.

The fill is not given.

Workmen are spaced at 5¼ feet intervals—roughly, 2 paces.

Day's task per man, 6.35 cubic yards.

Number of earth workers necessary: For excavation, 466; for leveling, 233; for carrying, 93; total, 792.

For bomb-proofs there are required 1,700 pieces of round timber 10 inches in diameter, 21 feet long; 35,425 running feet or 19,911 cubic feet. Also 30 carpenters for one week. Task per carpenter per day, 58.3 running feet.

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Estimate for the wire entanglement:

a Horizontal entanglement, 2,520 feet long, 21 feet wide; 6,126 pounds smooth and 31,500 feet barbed wire. Task 9.3 feet per day's work or 130 men to finish in one week.

b Vertical obstacle, 1,400 feet requires 100 men for 4 days.

Estimate for abatis, 1,750 feet; three days' work for 40 men.

For bunks 700 running feet are required. Allowing 2½ feet along the wall per man, we find that 280 men can be accommodated lying down.* The floor space is 7,840 square feet. The number of cells 22.

There are necessary two fire-places and forty ventilator-shafts.

Estimate of rails 21 feet long:

a	For the roof	2,200 rails	
b	For the splinter-proofs	150 rails	
c	For the vertical obstacle	400 rails	
	Total	2,750 rails	or 57,750 feet

The cost of the material is taken as $23,175.00.

The cost of construction, exclusive of transportation, $5,150.00.

The time for construction is five weeks. The greatest number of men employed at one time, 1,000.

The total cost is approximately $30,900.00.

MAJOR v. DEBNO-GOLOGÓRSKI.

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*The allowance for a man lying down is 2½′ x 6′ or 15 square feet. For 280 men 4,200 square feet are required, leaving 3,640 square feet for passages, etc. For bunks for 280 men 1,680 running feet are required or 4,200 square feet. The above estimate was evidently for men sitting when 2½ feet per man is allowed or 700 feet for 280 men.—Translator.

NOTE.—Latrines for the garrison should be provided inside the keep.—Translator.

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a Horizontal entanglement, 2,520 feet long, 21 feet wide; 6,126 pounds smooth and 31,500 feet barbed wire. Task 9.3 feet per day's work or 130 men to finish in one week.

b Vertical obstacle, 1,400 feet requires 100 men for 4 days.

Estimate for abatis, 1,750 feet; three days' work for 40 men.

For bunks 700 running feet are required. Allowing 2½ feet along the wall per man, we find that 280 men can be accommodated lying down.* The floor space is 7,840 square feet. The number of cells 22.

There are necessary two fire-places and forty ventilator-shafts.

Estimate of rails 21 feet long:

a	For the roof	2,200 rails	
b	For the splinter-proofs	150 rails	
c	For the vertical obstacle	400 rails	
	Total	2,750 rails	or 57,750 feet

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NOTE.—Latrines for the garrison should be provided inside the keep.—Translator.

EXAMPLE IV.

A provisional fort for two companies of infantry, sixteen guns to oppose the attack (Gegen-sturm-geschütz) and four guns to flank the interval.

By MAJOR-GENERAL KOSIUSKI, *Russian Army.*

[Mitteilungen, Jahrgang, 1904, Drittes Heft.]

Translated from the German by
FIRST LIEUTENANT ELLIOTT J. DENT,
Corps of Engineers, U. S. Army

(PLATE IV.)

In the plans of the work in question an endeavor is made to satisfy the following conditions:

A. The work belongs to a continuous line of defense.

B. It must be ready for defense in two weeks, and its interior must be completed in two and one-half months more.

C. The bomb-proofs must be proof against 6-inch (15 cm.) high-explosive shells and must shelter half the garrison sitting and half lying. In addition to this, the work must have safe magazines for the field-gun and rifle ammunition and bomb-proofs for the guns opposed to the attack.

A.

The first of the above conditions influences the trace of the work, the distribution of the garrison on the faces and flanks, and the strength of the parapet.

The trace is, comparatively speaking, long drawn out in order to make possible a strong frontal fire, a better defense of the interval, and a shallow target.

With field-guns at all ranges and mortars at a distance of 1,600 yards, the depth of the zone within which all shots will fall is taken as 233 yards, that within which 50 per cent of the shots will fall as 56 yards. The maximum lateral dispersion is assumed as one-half the longitudinal dispersion. On account of these distances the greatest depth of the work between firing lines, measured in the direction of the enemies' fire, is 82 yards. The dimension perpendicular to this line is 210 yards. A further reduction in these dimensions is not possible.

The garrison is distributed with two sections on the faces, three on the flanks, two in the gorge and orillons, and the remaining section as an inner reserve.

Strength of Parapet.

a The parapet is constructed as shown in Profile AA. By this form it is possible to sufficiently command the foreground, to prevent the inner work and bomb-proofs from being seen from the outside, and to shelter the banquette and emplacements from the action of shrapnel and rifle fire.

The angle of fall of caliber 30 bullets is 41′ 24″ at 600 paces, 1° 39′ at 1,000 paces, 3° 45′ at 1,500 paces, and 7° 38′ at 2,000 paces. For shrapnel from a 6-inch mortar at 1,600 yards range with full-size charge (3.8 pounds, approximately) the angle of fall of the axis of the cone of dispersion is, in round numbers, 11°. For three-fourths charge (2.8 pounds, approximately) it is about 17°.

In the profile of the faces the slope of protection is taken as 1:3 or approximately 18°. The height of the parapet is 14 feet on the faces, 9 feet in the gorge (Profile GG), and 7 feet in the orillons (Profiles CC, FF, and HH). The height of the latter is so chosen that the shallow ditch in its front is swept by frontal and enfilading fire without its being necessary to leave an interval between this ditch and the orillon. The orillon is shoved out the thickness of the parapet.

b The thickness of parapet of the faces is 35 feet, of the gorge and orillons 24 feet. This is made to resist the action of 6-inch high-explosive shells on the assumption that two shots may hit in the same place and thereby produce a 16-foot crater. (Experiments in 1886 at Fort Malmeson.)

c The slope of the superior crest of the faces is taken as 1:12 in order to be able to sweep the glacis with frontal fire without increasing its height above that given. To increase the effect of the frontal fire, a berm 2 paces wide is left behind the glacis. This may be used for a front line of infantry and as a sentinel's post. In the gorge and orillons the superior slope is 1:8.

d The depth of the ditches in front of the faces and gorge is so taken that the former may be flanked by at least three and the latter by at least two guns. The breadth of ditch in front of the orillons is determined by the breadth of the obstacle placed there.

The depth of the ditches is made such that the excavation would not be excessively difficult. Ascent from the ditch to the parapet is, however, impeded as much as possible.

Based on the above conditions the dimensions adopted for the ditches are as follows: The depth in front of the faces, 15 feet; in front of the gorge and orillons, 7 feet; the breadth of the gorge ditch, 38½ feet; of the other ditches, 56 feet.

The trace is a lunette with five salient angles, a gorge slightly reëntrant, and two orillons at the ends of the gorge. The latter serve to flank the face ditches and to oppose an approach to the gorge.

The face ditches, whose direction is independent of the faces, make a salient angle. The gorge ditch is flanked by a redan in its center. The shallow ditches in front of the redan and the orillons are protected by frontal fire, and in order to make an assault more difficult they are provided with obstacles.

To oppose the assault, there are three guns at each of the shoulder angles on platforms partly let into the parapet. These are 3-inch rapid-fire guns using fixed ammunition. They may be replaced by Maxim machine guns, or by 3.42-inch field guns if the use of shells is desired.

The guns to assist the neighboring works are 3.42-inch field guns and are placed on the platforms at the ends of the gorge. The location of these guns is based upon a drawing in which the forts are shown as lying along a circumference with a radius of 3.1 miles, the forts being 1.9 miles from each other. These guns are protected from enfilade fire by traverses 35 feet thick and 56 feet long. The platforms are 6 feet below the top of the traverses.

There are three 30-caliber Maxim machine guns in each orillon to flank the face ditches and two pieces on each side of the gorge redan.

In order to have the fort in a state of defense in two weeks and in order not to interfere with the parapet in finishing up the inside, all bomb-proofs are separate from the parapet.

In order to hasten the construction and to obtain the desired profile, all roofs are built of two rows of railroad iron and a concrete roof resting on them.

C.

Bomb-proofs for the guns opposed to the attack are placed near the gun platforms. That for the garrison is in a separate bomb-proof building in the inner work. The magazines lie between the orillons and the flanks.

The thickness of the concrete walls and roof is made as follows on the basis of experiments in Belgium in 1888:

The outer walls are 6 feet thick (in the magazines 8 feet). The wall nearest the gorge and the partition walls are 4 feet thick. The depth of concrete above the rails is 6 feet (for magazines 8 feet), and the depth of earth above the concrete is 2 feet, to hold the fragments of shells.

To prevent the wall on the gorge side from being undermined by high-explosive shells, "concrete mattresses" are constructed. (Profile EE.)

The drainage of the interior of the bomb-proofs is accomplished by means of drainage wells.

Since no openings are made in the bomb-proofs, the ventilation is accomplished by means of zinc pipes with conical top and bottom pieces. Charcoal fires are built under the lower ends to increase the draft. (Profile EE.)

The lighting is by oil lamps.

The work has two entrances, one on each side of the gorge-redan.

The garrison consists of:

	Officers.	Enlisted.
Two companies of infantry (442 rifles and 6 revolvers)	10	478
One and one-half machine gun companies	8	128
One-half light field battery	5	102
Total	23	708

Deducting 5 per cent for absentees, we have 673 men, for whom the following bomb-proofs are necessary:

15 casemates 49 feet long for men lying down, with one row of bunks.*
8 casemates 49 feet long for men sitting, with two rows of bunks.†
1 casemate for officers.
2 casemates for kitchens.
2 casemates for magazines.
1 casemate for telegraph and telephone station.
1 casemate for workshop.
30 casemates—total.

The allowance of casemates is as follows:

a 5 casemates for each infantry company.
3 casemates for the machine gun companies.
2 casemates for the half battery.
1 casemate for officers.
1 casemate for telegraph and telephone.
1 casemate for workshop.
2 casemates for kitchens.
2 casemates for magazines.

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*The bunks must be placed side by side the entire length of the casemate. Each casemate must hold 22.7 men (673÷(15×2), which allows 2.16 feet per man. The length of bunk is 6.3 feet. (See below.) The breadth of a casemate is 10 feet. (See scale of plan.) Width of passage 3.7 feet.—Translator.

†About 2.3 feet per man; width of bunks, 2.3 feet; width of passage, 5.4 feet.—Translator.

b For the men sitting:

5 casemates for infantry companies.
2 casemates for machine gun companies.
1 casemate for the artillery.

The allowance of ammunition is according to the following table:

Number.	Kind of gun.	Caliber.	Number of rounds of each kind per gun.				Total.	Dimensions of ammunition boxes in inches.			
			Canister.	Shrapnel.	Shell.	Cartridges.		Length.	Breadth.	Height.	
4	Light field-guns	3″.42	70	75	5	------	600	20.8	6.1	13.6	For projectiles.
								20.8	6.1	10.0	For cartridges.
6	Nordenfeldt rapid-fire guns	2″.444	750	200	50	------	6,000	17.0	12.0	25.5	See note.
10	Maxim machine guns	0″.30	----	----	---	5,850	58,500	29.0	17.0	8.0	
442	Infantry rifles	0″.30	----	----	---	500	221,000	16.5	13.5	5.0	
6	Revolvers	------	----	----	---	500	3,000	16.5	13.5	5.0	

NOTE.—Since this data for the Russian 3-inch rapid-fire gun is not known, the data for the Nordenfeldt 57 m. m. rapid-fire gun is given.

In order to facilitate the distribution of the ammunition, the entire supply is divided into two equal amounts and stored in separate magazines. A small amount of ammunition for the guns in the shoulder angles can be kept in the bomb-proofs provided for the guns.

a Six hundred rounds are required by the four guns assigned to support the adjacent works. Since five projectiles are packed in a box, 120 boxes will be required, or 60 boxes in each magazine. Since the width of the ammunition racks is 3½ feet, it will be best to store the boxes end to end in two rows with their length perpendicular to the length of the shelf. The length of the magazine is 21 feet, and the rack consists of two shelves, the first 1 foot above the floor and the second 3 feet above the first. (Profile HH.) Eighty boxes can be placed in one row, or 400 projectiles. Hence the above guns require a storage space of one shelf in the first compartment of each magazine.

b The boxes of powder cartridges are stored like those of projectiles. In one row on one shelf 80 boxes or 400 cartridges are stored, and for these cartridges one shelf of the second compartment is necessary.*

c For the six guns in the shoulder angles 6,000 rounds of fixed ammunition are required. Twenty-nine rounds are packed in a box, so that 207 boxes, or 104 for each half of the work, are necessary. Placing the boxes with their length perpendicular to the length of the shelf, each shelf will hold 40 boxes or 1,160 rounds. Less than three shelves are therefore required. This storage space would also be ample for the 3-inch rapid-fire guns.

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*It would seem better to put both projectiles and powder cartridges for the 3.42-inch guns in the same compartment of the magazine instead of using one shelf of each of two compartments.—Translator.

d The cartridges for machine guns are packed 450 rounds in a belt and one belt in each box. For 58,500 rounds 130 boxes are necessary, or 65 boxes in each half of the work. Placing the boxes with their lengths parallel to the length of the shelf, 16 boxes can be stored in one row or with two rows, 32 boxes on each shelf. Two shelves of the ammunition rack in the third compartment are sufficient.

e In order to seal them hermetically, the cartridges for the 30-caliber rifles are packed in zinc cases, each of which contains 20 smaller boxes with three clips of five cartridges each. Each ammunition box contains two zinc cases or 600 rounds. For 221,000 rounds 369 boxes are necessary, but allowing for absentees 368 or 184 in each magazine will be sufficient. Storing the boxes five deep with their length perpendicular to the length of the shelf, 184 boxes will require a little more than one shelf of the third compartment.

f For the six revolvers 3,000 cartridges are supplied. In a rifle ammunition box 120 packages of five cartridges each may be packed, giving a total of 600 rounds per box. Altogether five boxes are necessary, which can be stored on the second shelf of the third compartment.

Three shelves in the second compartment remain empty.

Finally there are given exact estimates of work, material, and prices. Of these only the important details are quoted below:

Fill, 51,435 cubic yards.

Excavation, 56,802 cubic yards.

Materials required:

To revet the parapet, 1,350 gabions 2½ feet high and 2 feet diameter.

To revet the steps, 418 fascines 18 feet long and 1-foot diameter.

For entanglements, 2,032 stakes 5 feet long and 1¾-inch diameter and 29,333 pounds, ⅛-inch diameter, wire.

Granite rock for foundations and concrete work, 15,748 cubic yards; 12,700 cubic yards concrete; 2,235 cubic yards Portland cement; 13,462 cubic yards broken stone, and 5,156 cubic yards moist sand.

Railroad iron for concrete roofs, 3,955 rails, 2,346,302 pounds.*

Bunks for men lying down, 6.3 feet long, 5,831 square feet.

Bunks for men sitting, 2.3 feet wide, 2,744 square feet.

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*593 pounds per rail, or 15.7 miles of rails, weighing 85 pounds per yard.—Translator.

Floor pavement consisting of clay, broken brick or tile, and hydraul lime, 14,700 square feet.

Floor of 3-inch round poles, 14,700 square feet.

Ventilator shafts of sheet zinc, 5.28 inches in diameter, 973 running fee

Sixty lamps.

The total weight of the material is 40,932 tons.

The estimated cost is about $116,000.00.

NOTE.—No provision has been made for latrines.—Translator.

EXAMPLE V.

A provisional fort for two companies of infantry and eight field guns.

By LIEUTENANT ZILTZOW,
Trans-Caspian, Sappeur Battalion.

[Mitteilungen, Jahrgang, 1904, Drittes Heft.]

Translated from the German by
FIRST LIEUTENANT ELLIOTT J. DENT,
Corps of Engineers, U. S. Army

(PLATE V.)

The plan is based upon the following assumptions:

The strength of the garrison is two companies (400 men). The armament consists of eight field guns, of which four are used to oppose an attack and four to sweep the foreground of neighboring works. The terrain is level, the depth of groundwater is 21 feet, and the class of earth ordinary. The work is a member of a continuous line of defense.

The direction of the faces and flanks conforms to that of the sides of the triangular ditch, which is built as an obstacle.

The triangular ditch is built with its base toward the enemy and not its vertex, as is usually done. This arrangement is the result of an endeavor to enfilade all the ditches without exposing the counterscarp galleries to direct artillery fire. In the given project this could not be avoided with the vertex toward the enemy. The form given has the additional advantage that the upper parts, as well as the soles of the ditches, are enfiladed for their entire length, which prevents crossing the narrow ditches with flying bridges.

The following requirements must be satisfied by the form of ditch chosen:

1. The ditches must not be less than 21 feet wide.
2. With the side slopes used the depth of ditch must not be less than 10 feet.

order to set a charge of explosives in the embrasure he must either open up the entanglement and lower himself through it, which would require special appliances, or he must climb over the network of wires, when he would find himself hanging over a ditch 20 feet deep. Neither could be done unnoticed, and hence the purpose of the obstacle is attained. A long halt above the gallery is theoretically impossible, since an enemy at that point would be subjected to the cross-fire of two guns.

GLACIS (Fig. 1).

The glacis is in front of the face only. The height of the crest of the glacis is diminished from the center toward both ends from 4½ to 4 feet. The slope of the glacis is from 1:14 to 1:15. At the ends of the front ditch the glacis slopes down to the natural level of the ground in order not to mask the canister fire of the guns in the faces.

Behind the glacis is a wide protected space upon and in front of which obstacles may be placed if desired.

LOCATION AND FORM OF THE FACE.

The trace of the fort may be seen in Fig. 1. The profile of the face is triangular with a height of 9 feet. The middle portion of the parapet has a slope of 1:10 and the wings a slope of 1:6. By this arrangement of slopes a step 9—5.4=3.6 feet high is formed between the above-mentioned portions of the parapet. This step is used to protect the guns of the face from frontal fire. The necessity for such cover is based on the fact that if the guns were placed in the salient angle without cover the gun details would incur such heavy loss that the guns would be put out of action early in the fight. The above location of the guns has the additional advantages that it does not mask any portion of the work. It affords the necessary cover for the gun details, and it permits the fire of two guns to be concentrated to oppose an assault directed against the center of the work, the most certain point of attack.

Besides these two gun platforms there are two others on the middle portion of the face. They are higher and give a frontal fire.

In each shoulder there is an emplacement for two guns to prevent a powerful attack from breaking through the interval. This arrangement seems allowable, since, according to the project, the most probable time for such an assault is the beginning of the siege, when the fire of the attack is not very effective. The effect of the enemy's fire is further diminished by the small command of the fort, its inconspicuous profile, and its uncertain location at this stage of the combat.

The height is taken as 9 feet in order to give the necessary command of the surrounding country and also to enable casemates for sweeping the

3. The equality of excavation and fill must be maintained.

In compliance with the foregoing, the breadth of the front ditch is 31½ feet at the ends and 21 feet at the middle, where its counterscarp makes a reëntrant angle. The profile of the flank ditches is the same as that of the middle point of the front ditch. The depth of all ditches is 10 feet. The slopes of the scarp and counterscarp are 2:1 or 5:1, according to their location with respect to the enemy. (Profile AA.)

The front ditch is secured by two field guns, one in each end. This arrangement subjects every point of the ditches to canister fire. The above-mentioned narrow part of the front ditch, which might entice an assailant to try to force a crossing, is secured by four guns, two on the faces and two in the counterscarp galleries (Fig. 1). The flank ditches are each enfiladed by one gun of the counterscarp galleries. This is sufficient, since an attempt to cross these ditches can be opposed by canister from the guns of the gorge-redan. Only four guns are therefore necessary for ditch defense. They are placed in two counterscarp casemates. The ramps for crossing the ditch at the rear vertex of the triangle may be swept by cross-fire from both counterscarp galleries.

The assertion is made by the opponents of the triangular trace that the great length of the ditch will materially increase the cost of the work and will also make it difficult to fit the work to the ground. On the other hand, the ditch in this case needs no revetment, which is a large item of cost, especially in permanent works. The length of ditch is determined by the amount of earth required. Moreover, in spite of its disadvantages many works have this form of ditch.

COUNTERSCARP GALLERIES.

Each counterscarp gallery consists of two casemates, a passage connecting them, and a magazine opening into this passage. Between the casemates is a passage for single men 4 feet wide and opening on the ditch* (Fig. 1).

The entire outwork is covered with a concrete roof 4 feet thick (according to Wagner, 3 feet is sufficient protection against 6-inch shells). In order to prevent the enemy from attacking this outwork with explosives, the ditch in its front is deepened to 20 feet, and overhanging the depression thus formed is a horizontal obstacle. This obstacle consists of rails 7 feet apart with one end imbedded in the concrete and a wire entanglement on the projecting portion. The wire is so fastened that if a rail is struck and falls to the bottom of the ditch it will not carry the entanglement with it. If an enemy were to reach the counterscarp gallery, in der to set a charge of explosives in the embrasure he must either open the entanglement and lower himself through it, which would require ecial appliances, or he must climb over the network of wires, when he ould find himself hanging over a ditch 20 feet deep. Neither could be ne unnoticed, and hence the purpose of the obstacle is attained. A long lt above the gallery is theoretically impossible, since an enemy at that int would be subjected to the cross-fire of two guns.

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*A flying bridge which is drawn inside the casemate serves to cross the deep portion of the ditch in front of the counterscarp gallery.

GLACIS (Fig. 1).

The glacis is in front of the face only. The height of the crest of the acis is diminished from the center toward both ends from 4½ to 4 feet. he slope of the glacis is from 1:14 to 1:15. At the ends of the front tch the glacis slopes down to the natural level of the ground in order t to mask the canister fire of the guns in the faces.

Behind the glacis is a wide protected space upon and in front of which stacles may be placed if desired.

LOCATION AND FORM OF THE FACE.

The trace of the fort may be seen in Fig. 1. The profile of the ce is triangular with a height of 9 feet. The middle portion of the parapet s a slope of 1:10 and the wings a slope of 1:6. By this arrangeent of slopes a step 9—5.4=3.6 feet high is formed between the aboveentioned portions of the parapet. This step is used to protect the guns the face from frontal fire. The necessity for such cover is based on e fact that if the guns were placed in the salient angle without cover e gun details would incur such heavy loss that the guns would be put t of action early in the fight. The above location of the guns has the ditional advantages that it does not mask any portion of the work. It fords the necessary cover for the gun details, and it permits the fire of vo guns to be concentrated to oppose an assault directed against the enter of the work, the most certain point of attack.

Besides these two gun platforms there are two others on the middle ortion of the face. They are higher and give a frontal fire.

In each shoulder there is an emplacement for two guns to prevent a owerful attack from breaking through the interval. This arrangement eems allowable, since, according to the project, the most probable time or such an assault is the beginning of the siege, when the fire of the ttack is not very effective. The effect of the enemy's fire is further iminished by the small command of the fort, its inconspicuous profile, nd its uncertain location at this stage of the combat.

The height is taken as 9 feet in order to give the necessary command f the surrounding country and also to enable casemates for sweeping the interval to be built under the flanks. If, for example, the height of the floor of these casemates be taken as 0.0 feet and the ceiling as 6 feet, the thickness of the concrete roof will still be 3 feet at the interior crest. In view of what has preceded this is sufficient.

The triangular profile of the parapet serves to eliminate the dead space which would otherwise exist between the scarp and exterior slope and also furnishes a space on the parapet in which to use the bayonet. The length of the face is computed for three sections, 150 men.

Beneath the middle portion of the face are bomb-proofs built according to the plans of Professor Engman. Their size is computed for 180 men, of whom thirty are artillerymen. The width of the casemate is 7 feet, and a length of 6 feet is allowed for every six men. Three men are in bunks one above the other, and the remaining three are sitting. Three covered entrances lead from the parade to the bomb-proof. The thickness of roof is 3 feet.

On each side of the bomb-proof for the men is one 8 feet wide and 6 feet high for a field gun. These are also provided with a concrete roof 3 feet thick. They open directly on the parade. Behind these gun recesses is a gallery 5 feet wide for ammunition. It is connected with the main bomb-proof by a covered passage. The thickness of this roof is also 3 feet. The outside wall of the gun recess has a "concrete mattress" to prevent its being undermined by shells.

The rapidity with which the guns can be brought into action in either the 2 or the 5-foot-high emplacement is hastened by the fact that when in their recesses they are already at the height of the plane of site and at the foot of the ramp leading to the emplacements.

THE FLANKS.

These can be discussed in connection with the gorge. They are made bomb-proof, and one-half serves as a bomb-proof and casemate for 75 men, while the other half furnishes emplacements for field guns.

In case of an assault the infantry man the loop holes in the rifle gallery parallel to the living quarters. This arrangement has the following advantages:

a It increases the proportion of the garrison ready to take their posts at an instant's notice.

b It will assist the defenders in making a counter-attack in case the face is captured, since the flanks may be held an indefinite time. (Fort Kanly, during the siege of Kars, 1877.)

c It strengthens the defense of the interval by the 75 rifles on each flank.

d It makes it possible, by the use of search-lights, to subject the interval to a powerful rifle fire at night up to a distance of 1,500 paces.

The last feature is especially important when the fort is subjected to such a heavy artillery fire that only three instead of all eight field guns can be used against the interval.

The living quarters are built low down (floor —5 feet) and have a width of 8 feet. The rifle galleries are somewhat higher (floor —4 feet) and are 4 feet wide.

The roof of the bomb-proof is sloped and consists of a sheet of concrete on a layer of railroad iron. The rails are supported at one end by the outer concrete wall and at the other they rest on the original surface of the ground.

Three casemates for field guns are built in each flank. The inner partitions are brick walls 3 feet thick. The casemates are 10 feet wide and 6 feet high. Their roof is 3 feet thick. The "concrete mattress" is 4 feet thick, and its base is 1 foot below the plane of site. Under this mattress and opening into a gallery beneath the gun platforms are niches for cartridges and projectiles. The gallery is connected with the casemates by three openings in its roof, through which the ammunition is passed.

One of the three flanking guns remains always in its casemate and acts as a "counter-storming gun" (gegen-sturm-geschutz) by opposing an attack against a neighboring work.

GORGE.

In front of the gorge is a redan, circular in trace, and with a triangular profile 6 feet high. Along the crest of the redan is a banquette for fifty rifles at 7-foot intervals, two embrasures cut into the parapet for counter-storming guns, and two gun platforms for three guns each with ramps leading to them.

The ramp leading from the middle of the redan to the sole of the ditch is guarded by frontal fire.

In the gorge itself is a bomb-proof for 100 men, the reserve. It is also built on the Engman type, and from it a gate leads to the parade and stairs connect it with the bomb-proofs of the flanks.

GARRISON.

The garrison consists of two companies of infantry and artillery detachments for twelve guns (eight guns in the interior work and four in the ditches). Three sections of infantry are provided for under the face, one and one-half sections and the detachments for three guns under each flank, and the remaining two sections in the gorge bomb-proof.

The garrison of the gorge (twenty-five men from each flank bomb-proof) must occupy the redan as well as the flank casemates. They also assist in getting the counter-storming guns into their emplacements.

The bomb-proof for the commandant and the other officers is in the flanks.

Niches for cartridges are constructed along the parapet. Along the faces they are built with mining frames. Along the flanks they are built in the concrete walls. In the magazines projectiles and cartridges are stored on shelves.

VENTILATION OF BOMB-PROOFS.

This is accomplished by means of round ventilator shafts through the concrete roof. They are 6 inches in diameter below, 5 inches in diameter above, and are spaced at 7-foot intervals.

During a heavy bombardment of the fort, when the penetration of gases through these ventilators is to be feared, they may be closed above by wooden blocks. During such periods ventilation would be obtained by means of fans, for which niches in the walls are provided. Each fan is run by hand by means of a wooden pulley and a belt. The niches are connected with the outer air and with the bomb-proof by suction tubes. For each section there are four niches, through two of which the air is sucked in, and through the other two the foul air is forced out.

The strength of the firing lines is made up as follows:

For frontal fire there are 150 men on the faces. To give the rifles the proper elevation to graze the glacis, 75 men have rests attached to the guns. The remaining 75 aim by means of the slope of the superior crest, giving their guns the proper elevation with their hands.*

From the same line the field guns in the faces deliver an oblique canister fire in the direction of the flanking galleries.

The flanks are secured by frontal fire from fifty men in each casemate and enfilade fire from ten men in the gorge-redan.

One gun in the redan sweeps the approach to each flank. It fires through an embrasure to prevent the work from being unmasked and in order to afford better protection to the gun detachment. It covers the ground above the counterscarp gallery.

On account of the concentration of the fire of the field guns in the direction of the counterscarp galleries it will be impossible for an assailant to halt in their neighborhood so long as the guns remain in action. Thanks to their location, the latter cannot be injured. But if the assailant must remain at a distance from the counterscarp galleries the latter may be depended upon to the last moment. Hence under the assumption "That so long as one gun can enfilade the ditch it cannot be crossed by n assaulting party," the designer arrives at the theoretical conclusion that he fort cannot be taken by force.

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*This apparently refers to aiming at night, when the sights cannot be used.—Translator.

On account of the above-mentioned location of the field guns, which completely cover the surrounding ground, the defense of the closer foreground by rifle fire becomes less important, and the enemy should therefore be opposed at the earliest possible moment—*i. e.*, at long range (933 yards).

The above distribution of the means of defense will hold until the moment that the enemy crosses the ditch. At this moment the best way to repulse the assault is with a bayonet charge by the reserve, assisted by rifle and field-gun fire.

The separate parts of the work are connected partly by telephones with wires unprotected and partly by means of iron speaking-tubes 2 inches in diameter laid on top of the ground.

The latrines are built on the cess-pool system and are under the concrete mattresses. A supply of slaked lime is kept at hand to disinfect the deposits.

Drinking water is led into the fort by means of a canal. During the bombardment warm food is prepared at night.

The plans are based upon a southern climate and a particular class of ground, but its details can be altered to meet special conditions—as, for instance, in regions where there is little rainfall the precautions to prevent water from running into the bomb-proofs may be omitted. In the given case the warm climate rendered stoves for the bomb-proofs unnecessary.

The inner space is covered with reeds. Grass mats are useful for this purpose.

Estimate of labor, material, and cost:

Excavation, 19,431 cubic yards; fill, 21,336 cubic yards. For excavation, moving, and leveling a task of 5 cubic yards is assumed for one man for twelve hours. For excavation, etc., 800 men are required for two days and 300 for the remaining time, seven days.

The concrete is estimated at 4,216 cubic yards. The amount of finished concrete per day of twenty-four hours, with reliefs of 600 men working continuously, is taken as 762 cubic yards. All concrete work is finished in six days, or on the ninth day.

The foundations and walls measure altogether 482 cubic yards and necessitate 168 masons or 60 masons for three days.

From the second to the fifth day forty carpenters are required; from the sixth to the tenth, 100 men daily. In this manner the fort may be finished in the rough in ten working days.

The cost is as follows: Earthwork, $966.00; concrete work, $28,325.00

($6.50 per cubic yard concrete and $13.40 per cubic yard brick work rails, $10,300.00; carpentry work, laying temporary railroads, lightin telephones, obstacles, and other work, $1,600.00; total, $41,200.00, whic is given as the cost of the work complete.

(Signed) MAJOR v. DEBNO-GOLOGÓRSKI.

NOTE.—There is apparently no opening for guns to be taken in or out of t counterscarp galleries.

The work is designed to resist the action of 6-inch shells instead of 8-inch, whi accounts for the thinner roof. In any case this roof should have a thin covering earth to reduce the effect of percussion shells.

EXAMPLE VI.

A half-permanent fort for two companies of infantry and eight field guns.

By

FIRST LIEUTENANT BUJNICKI.

[Mitteilungen, Jahrgang, 1904, Siebentes Heft.]

Translated from the German by
FIRST LIEUTENANT ELLIOTT J. DENT,
Corps of Engineers, U. S. Army

(PLATE VI.)

As the last example in the series of projects of Russian engineer officers already published in the first, second, and third numbers of the "Mitteilungen" for 1904 and illustrating the Russian practice the plan shown on Plate VI will be given. This was published during the past year by the well-known military writer, First Lieutenant Bujnicki, in a work entitled "The Present Situation of the Art of Permanent and Provisional Fortification." Since this book was published by the management of the "Nicolas Engineer School and War College," the examples contained in it must represent the official Russian technical standpoint.

The above plan belongs, according to Russian nomenclature, to the "half-permanent" class and is based on the following assumptions:

1. The work, designed for two companies of infantry and eight field guns, forms an angle in a line of defense surrounding an important strategical point.

2. The total allowable time for the completion of the fort is three months; but two weeks from the time work is begun it must be capable of self-defense, and its ability to defend itself must not be lessened by work necessary to complete it.

3. It must hold a maximum of 1,000 men.

Fig. 1 shows the fort after its completion, while Fig. 3 shows its condition at the end of two weeks. Finally, Fig. 2 represents the case when for some reason the concrete bomb-proofs are replaced by provisional splinter-proofs which may be built in four weeks. In order to accomplish the above objects in the simplest manner, but especially to obtain the defensive strength in fourteen days, the depth of ditch and height of parapet are each taken as 10½ feet. With these dimensions the author believes that the work necessary to prepare the fort for self-defense can be finished in the time given. This includes the preparation for the construction, the excavation, the fill, and the clay revetment of the parapet.

The face ditches are flanked from casemates connected with the interior by a gallery. Since to construct this requires more than two weeks, Bujnicki proposes for the preliminary construction a redan instead of the casemates and an open passage through the parapet instead of the gallery. He gives the parade of the redan and the sole of the passage the depth necessary in order to construct the casemates and gallery at a later period without disturbing the temporary open flanking work. By a comparison of Figs. 1 and 3 it is seen that the shallow ditch, swept by frontal fire from the redan, is in the final construction used as an obstacle to project the caponier and is swept by fire from the faces.

In reference to the remaining bomb-proof structures no special provisions are necessary, since they are located in the interior of the fort and are entirely independent of the preliminary work. The only requisite is that its dimensions are such that on the fourteenth day the necessary material to cover the bomb-proofs shall be available, no matter whether the final form be a concrete roof with a thin earth covering or a wooden roof with a thick covering. The substitution of concrete roofs for wooden ones or for mining galleries and the difference in cover affecting the amount of earthwork remaining may be seen in Profiles GG, KK, and LL.

The distribution of the infantry is as follows:

	Men.
One section on each face	100
One section on each flank	100
Two sections in the gorge	100
Two sections as interior reserve	100
Total	400

Twenty-five men are taken from the reserve to garrison the redan at the salient angle. Two tiers of fire are provided on the flanks in order to strengthen the fire in the direction of the adjoining works.

The two field guns in each shoulder serve to assist the frontal rifle fire. These guns and their detachments are sheltered in the front part of the bomb-proof. Two guns are placed on each side of the double gorge redan, where they can fire against an enemy attempting to break through the interval. During quiet intervals they are in the gorge casemate, which guards the entrance to the fort.

The fort is secured against assault by a ditch of trapezoidal cross-section enfiladed along the faces by rifle fire from the caponier and along the gorge by field guns in the redan. As already stated, the caponier is protected by a shallow ditch which is covered by frontal fire from the faces and by oblique field-gun fire from the shoulders. The ditches of the double redan are flanked by the in-drawn portions of the firing line. The ditches are provided with wire obstacles.

An open passage connects the fort with the outside. The entrance is subjected to cross-fire from the surrounding firing lines of the double redan and the two embrasures in the gorge bomb-proof.

The following are the most important estimated items for the construction of this fort. They are taken from the above-mentioned book.

a During the first two weeks, first period, there will be completed: the preparation (laying out of the work), two days; the earthwork to bring the fort to the stage shown in Fig. 3, ten days; the clay revetments and entanglements, two days. Estimate of laborers: Daily, except the first two and last two days, 524 earth-workers, 262 levelers, 104 dump-cart men, 10 carpenters, and 100 helpers or sappers; for the last two days, 1,000 laborers, among whom are 300 sappers.

b During the following three weeks (second working period, third to fifth week) there will be finished: the transportation of materials to the place; the excavation for foundations; the walling up of the foundation, and the placing of the forms for concrete work. Estimate of laborers: Daily, 450 wheelbarrows and men to run them, 135 helpers, 100 carpenters, 100 laborers; from the thirteenth to the twenty-first day, 100 earth-workers, 50 levelers, 20 dump-cart drivers, 2 carpenters; from the twenty-ninth to the thirty-fifth day, 57 masons and 43 helpers.

c During the remaining two weeks (third working period, sixth and seventh week) the concrete work is finished. Estimate of laborers: Daily, 531 helpers, 66 masons, 18 carpenters, 150 wheelbarrow men, and 6 schlossers.*

d During the last four weeks (fourth working period, eighth to eleventh week) there will be finished: the removal of the concrete forms, covering the roof with the revetment and leveling of its slopes, the interior arrangements of the bomb-proofs, and the final touches. Estimate of laborers: A daily average of 150 men and 15 carts.

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*A schlosser is a tradesman who does light architectural iron work, such as hinges, hasps, iron railings, etc. He both makes them and places them in the building.—Translator.

The greatest number of workers of the various classes required at one time is as follows:

Five hundred and twenty-four earth-workers and wheelbarrow men, 262 levelers, 104 horse carts—during ten days, from the third to the twelfth day—300 sappers, thirteenth and fourteenth days; 100 carpenters, 450 wheelbarrows, 66 masons.

The largest fatigue detail required at any time is 1,000 men. The total time of construction is eleven weeks or two and one-half months.

The measurements of material and cost of the work are as follows:

39,852 cubic yards excavation at	$0.23	$4,707.00
17,903 square yards leveling	.05½	1,645.00
20,889 square yards revetment	.09	192.00
11,043 square yards wire entanglement	.10	1,104.00
16 joch* land	50.00	800.00
1,286 cubic yards foundation masonry	8.00	10,196.00
4,673 cubic yards concrete	11.80	27,570.00
3,831 days' work	0.75	2,873.00
Total cost		49,087.00

To provide for unforeseen contingencies, the total cost may be taken as $50,000.00.

*The joch is a measure of land.

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WATER SUPPLY OF WASHINGTON.

The water supply of Washington received attention and consideration contemporaneously with the original laying out of the city. At that early period the Potomac above Great Falls, Rock Creek and the Eastern Branch of the Potomac, the numerous springs within the city limits, and the smaller springs in the vicinity were all contemplated as sources of supply.

Numerous surveys were made by Major L'Enfant, under the direction of General Washington, to ascertain the practicability and feasibility of obtaining a full and good supply of water for the Federal capital.

The immense volume of water discharged over the Great Falls of the Potomac indicated this as the point whence a certain and abundant supply could be obtained; the only argument against it was the expense of bringing the water to the city.

In 1850 the Thirty-first Congress, by "An act making appropriation for the civil and diplomatic expenses of the Government for the year ending the thirtieth of June, eighteen hundred and fifty-one, and for other purposes," approved September 30, 1850, appropriated the sum of $500 to enable the War Department to make such examinations and surveys as may be necessary to determine the best and most available mode of supplying the city of Washington with pure water, and to prepare a plan and estimate of the probable cost of the same, to be reported to Congress at its next session."

In accordance with the above act, on January 25, 1851, Mr. C. M. Conrad, then Secretary of War, submitted to Congress the report of Brevet Lieut. Col. George W. Hughes, Corps of Topographical Engineers.

The report considers and discusses two sources of supply, the Potomac at Great Falls, and Rock Creek.

Owing to insufficient data in respect to the Great Falls supply, due to the small amount of the appropriation ($1,500), the city of Washington having added $1,000 to the funds available, the Great Falls project was not gone into, but the survey and investigation was confined to the Rock Creek project. Colonel Hughes proposed, by building a dam to obtain from Rock Creek a possible supply of 8,000,000 gallons per diem, and this was considered adequate to supply the city for the following forty years.

Washington at the time (1851) contained, by the recent census, 40,027 inhabitants. It was proposed to supply 1,500,000 gallons daily; this was considered at the time ample, being more than 30 gallons per capita per diem. Colonel Hughes says:

"This is the highest calculation I have seen, and is, no doubt, ample for uses for a city, except for manufacturing purposes."

In the above project a sedimentation reservoir was proposed, located on Meridian Hill, with a distributing reservoir "to be established just back of Franklin road, the highest ground within the city;" this location was Eleventh and N streets, northwest. The surface of the water in the distributing reservoir was to be 147 feet above ordinary low tide, or 57 feet above the eastern base of the Capitol. The level of water in the sedimentation reservoir was to be 160 feet above low tide, and the water for fountains and a "great jet d'eaux" was to be drawn directly from this level. The estimated cost of this project was $500,000.

The water supply of Washington is now derived from the Potomac River, taken at Great Falls, 14 miles above Washington. The project and estimate for delivering this water to the city of Washington originated with Capt. M. C. Meigs, Corps of Engineers, United States Army.

In 1852 the Thirty-second Congress, at its first session, appropriated $5,000 to enable the President of the United States to cause to be made the necessary surveys, projects and estimates for determining the best means of affording to the cities of Washington and Georgetown an unfailing and abundant supply of good and wholesome water.

Under this order of Congress the surveys were made in the winter of 1852–53, and the report of Lieut. Meigs, dated February 12, 1853, was, on February 22, ordered to be printed, and will be found in Senate Ex. Doc. No. 48, Thirty-second Congress, second session. Projects with careful estimates and elaborate details were prepared, showing the best mode of procuring this water supply.

Congress, after a full discussion and consideration of the project, agreed to a provision in the general appropriation bill approved March 3, 1853, appropriating—

"For bringing water into Washington, upon such plan as the President of the United States may approve, one hundred thousand dollars: ***Provided***, That if the water shall be taken from any place within the limits of Maryland, the consent of the State shall first be obtained."

The President of the United States, acting under the requirements of this law, adopted the project described in the report and estimate of Lieut. Meigs—that is, the aqueduct from the Great Falls of the Potomac, with a conduit 9 feet in diameter. The State of Maryland passed an act granting her consent, ceding jurisdiction over the lands to be acquired for the aqueduct, and authorizing the appraisement and condemnation of lands in case the owners would not agree to sell them on reasonable terms.

The project contemplated a dam at Great Falls to hold the water at a proper level, whence it was to be conducted by a circular conduit of brick 9 feet in diameter, having a fall of 9½ inches to the mile. The level of the comb of the dam was to be 145 feet above high tide at Washington.

The project contemplated two reservoirs, a receiving reservoir (Dalecarlia) and a distributing reservoir. The receiving reservoir was formed by damming Little Falls Branch, a tributary of the Potomac situated along the line of the conduit, about 4½ miles from Washington. Its area is 50.651 acres and its capacity, above the level of 140 feet above mean tide is, 82,521,500 gallons. This reservoir acts not only as a storage reservoir, but also as a sedimentation basin. As originally constructed it also added to the water supply by gathering the surface water from its watershed, which was considerable. The water enters this reservoir by a tunnel at a distance of half a mile from the point at which it leaves it. The reservoir naturally shortens the conduit and saves the expense of an aqueduct bridge over Little Falls Branch.

The distributing reservoir, situated about 2 miles from Washington on the heights beyond Georgetown and connected with the receiving reservoir by a continuation of the conduit, is formed by an embankment of earth surrounding a favorable site. The area of its water surface is 36¾ acres, its level when full was 145 feet above tide, its contents, above 140 feet, is 59,784,000 gallons, and its total contents 167,530,000 gallons.

The two reservoirs are designed to afford, should the conduit be obstructed by floods or interrupted by accident, or during the periodical examinations necessary for repair, 142,530,000 without reducing the head below 140 feet; and in case the level be lowered to 131 they would yield 250,000,000 gallons, besides what would be supplied from the watershed of the receiving reservoir on Little Falls Branch.

The mains which led the water to the city from the distributing reservoir were two, one 30 inches in diameter and one 12 inches in diameter. The size adopted was considered ample for the supply for some years after the completion of the aqueduct; the distribution of the water to the several parts of Washington was by smaller distributing mains laid by the city. As the demand for water increased with the growth of Washington, two other mains were added, a 36-inch main in 1873 and a 48-inch main in 1890, so that at present the supply is received through four mains—one 48-inch, one 36-inch, one 30-inch and one 12-inch main.

A part of Georgetown, being too high to take water by gravity alone, was supplied from a ***high service reservoir filled by pumping machinery.***

The estimated daily capacity of the aqueduct was 67,560,400 gallons, and its estimated cost, including distributing mains to the various public buildings, which were also to be used for the city supply, $2,271,244.

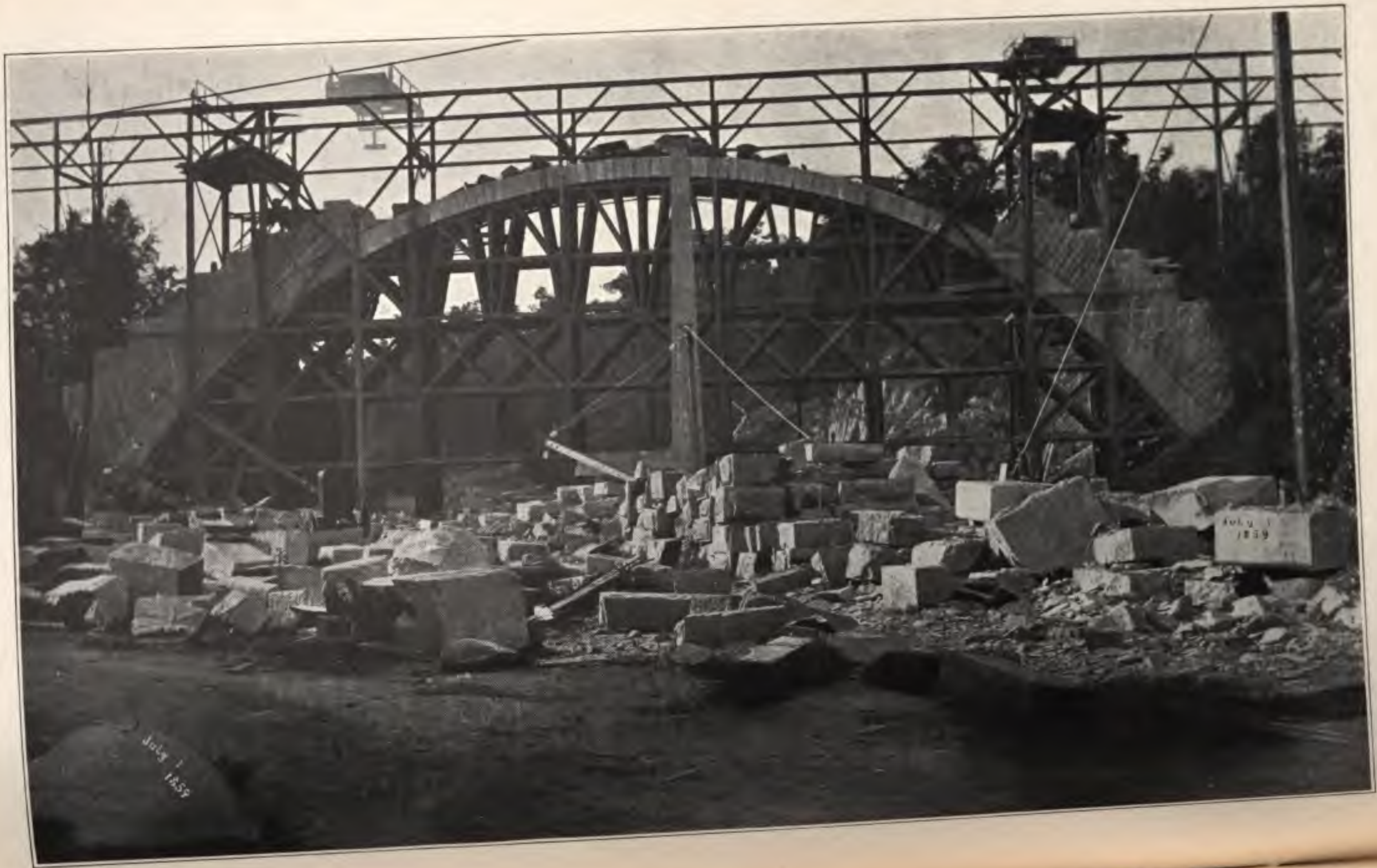
The estimated population of Washington in 1852 was 49,339. Georgetown, by the census of 1850, contained 8,366 inhabitants, making a total to be supplied by the water system of 58,000.

The aqueduct, according to the above project, was so far completed in 1859 that the water from the receiving reservoir was available and turned into the mains. This supply was independent of the Potomac and was furnished by the watershed of Little Falls Branch. The conduit was completed and water supplied from the Potomac December 5, 1863, and since that date the system has been in successful operation.

It was found that the receiving reservoir was frequently rendered very turbid from sudden rises in Little Falls Branch and from surface drainage, thus making the water supply objectionable. To avoid this trouble a by-conduit was built carrying the Potomac water round the receiving reservoir, and it was intended to use the reservoir only when in suitable condition as to turbidity or otherwise in case of emergency.

The constant turbidity and impurity introduced by the watershed draining into the receiving reservoir was finally remedied in 1895 by collecting this surface water and draining it into Little Falls Creek below the reservoir.

At the time of the first introduction of the Potomac water, the dam at Great Falls was a riprap dam and extended across the Maryland channel only. At low water in the Potomac constant difficulty was encountered in obtainining a sufficient supply of water. This was partially obviated by extending temporary dams above Conns Island, which was on the west side of the Maryland channel, and clearing out this channel by the removal of rock from the bottom. The riprap dam required constant


July 1 1899
July 1 1899

repair after the damage caused by spring freshets and the run out of the ice.

In 1886 this dam was replaced by a masonry structure which was extended to the Virginia bank of the Potomac at a level of 148 feet above mean tide water at Washington and was finally, in 1896, raised to the level of 150.5 above the same level.

The capacity of the conduit after the raising of the dam was 76,500,000 gallons per diem when the water in the distributing reservoir was held at a level of 144.

This last amount may be considered as the present capacity of the Washington water system, as a lower height in the reservoir than 144 would so materially decrease the pressure in the mains that a marked lowering of the gravity supply would result.

With the present head a large part of the city can not be supplied by gravity. This portion is supplied by direct pumping and by a high-service reservoir at Fort Reno, to which the water is pumped by the District Commissioners.

To recapitulate, the following is a concise description of the present Washington Aqueduct system:

The water supply is taken from the Potomac River at Great Falls, about 14 miles above the city.

At this point a masonry dam extends across the river from the Maryland to the Virginia shore. Its total length is 2,877 feet, and the width of its crest in the Virginia channel and across Conns Island is 8 feet, 3 inches and in the Maryland channel 7 feet, 9 inches. In 1895–96 the crest of the dam was raised from reference of 148 feet above mean tide at the Washington Navy Yard to 150.5 above the same datum plane.

The top of the mouth of the feeder of the conduit at Great Falls is at a reference of 149 feet and the bottom at a reference of 139.5 feet.

The water passes from the feeder through the gatehouse and into the conduit, which at this point has a reference of 152 feet at the interior surface of the crown of the arch.

The slope of the conduit is uniform between the gatehouse at Great Falls and the distributing reservoir and is 9 inches in 5,000 feet.

The conduit is circular in cross section, and for the greater part of its entire length is 9 feet in diameter and composed of rubble masonry plastered or of 3 rings of brick, but where the soil in which it was built was considered particularly good the inner ring of brick was omitted and the diameter is 9 feet, 9 inches. Where the conduit passes as an unlined tunnel through rock the excavation was sufficient to contain an inscribed circle 11 feet in diameter.

The lengths of the conduit and its connections are as follows:

Length of feeder at Great Falls, 256 feet.

Area of cross section at mouth, 157.45 square feet.

Length of conduit between gatehouse at Great Falls and north connection of Dalecarlia Reservoir, 47,896.5 feet; least diameter, 9 feet.

Length of by-conduit around Dalecarlia Reservoir, 2,730.5 feet; diameter for 625 feet, 8 feet; for rest of distance, 9 feet.

Length of conduit between south connection of the Dalecarlia Reservoir and north connection of the distributing reservoir, 10,149.87 feet; diameter of conduit, 9 feet.

Length of by-conduit around the distributing reservoir, 2,274.35 feet; diameter, 7 feet.

At the distributing reservoir the watet passes into four cast-iron mains, 48 inches, 36 inches, 30 inches and 12 inches in diameter, respectively.

The Dalecarlia Reservoir has a storage capacity of about 150,000,000 gallons; is practically without paved slope wall, is perfectly protected against pollution from the drainage of the surrounding country, and is provided with a spillway, the reference of the bottom of which is 146.5 feet. The reference of the interior surface of the crown of the arch of the conduit at the north connection of this reservoir is 143.77 feet and at the south connection 143.39 feet. The distance between these points, measured along the line of flow of the water across the reservoir, is about 3,550 feet.

The distributing reservoir has a storage capacity of about 150,850,000 gallons and is divided by a puddled and paved wall, through which is a passageway which can be closed with stop planks, into two sections containing 97,600,000 and 53,250,000 gallons, respectively.

The interior surface of the crown of the arch of the conduit at the north connection of this reservoir has a reference of 141.87 feet.

In addition to the three reservoirs already mentioned, which form a part of the aqueduct system, there is another reservoir, built and controlled by the Commissioners of the District of Columbia, called the Fort Reno Reservoir, with a capacity of about 4,500,000 gallons, the reference of its water surface, when the reservoir is full, being about 420 feet.

The Dalecarlia and distributing reservoirs supply the U street pumping station and that part of the District which lies below 90 feet above datum. The areas lying between the levels of 90 and 220 feet above datum are supplied by pumping from the U street station directly into the distributing mains, and by the use of the new Brightwood reservoir, built by the Commissioners of the District of Columbia, and having a capacity of 30,000,000 gallons, the Georgetown high-service reservoir being held as

a reserve supply. The areas having a greater elevation than 220 feet above datum are supplied from the Fort Reno reservoir.

It will be observed, therefore, that the total present storage capacity of all reservoirs is about 337,000,000 gallons, or about six day's normal supply.

There has just been completed, for increasing the water supply of Washington, a tunnel from the present distributing reservoir to a new reservoir situated near the Howard University.

The new reservoir has a capacity of 300,000,000 gallons, thus raising the capacity of storage to 637,000,000 gallons.

The new reservoir, being situated about 4 miles east of the present distributing reservoir, will occupy a more central distribution point, and thus somewhat reduce the loss of head now obtaining at Capitol Hill and east thereof. The level of water in this reservoir will be 144, and its estimated will add about 15 feet additional height to the water delivered at Capitol Hill.

Until the average daily consumption of water becomes considerably greater than at present, the reference of the surface of the water at the lowest stage of the Potomac will be about 151 feet at the mouth of the feeder at Great Falls; about 146.75 feet at the Dalecarlia Reservoir, and 146 feet at the distributing reservoir.

The following table gives the daily consumption of water by the District of Columbia as furnished by the Washington Aqueduct for the last twenty-eight years:

Date.	Daily consumption.	Population.	Amount per capita per diem.
	gallons.		*gallons.*
1874	17,554,848	*a*130,182	134
1875	21,000,000	*a*138,091	152
1876	24,177,797	*a*146,000	165
1877	23,252,932	*a*153,909	151
1878	24,885,945	*a*161,818	154
1879	25,947,642	*a*169,727	153
1880	25,740,138	*b*177,638	145
1881	26,525,991	*a*182,893	145
1882	29,727,864	*a*187,968	158
1883	24,314,715	*a*193,133	126
1884	24,827,113	*a*198,198	125
1885	25,219,194	*c*203,459	124
1886	25,542,476	*a*208,358	123
1887	26,878,424	*a*213,357	126
1888	29,115,774	*a*218,157	133
1889	27,708,779	*a*225,309	123
1890	35,541,845	*b*232,460	153
1891	38,594,743	*a*248,539	155
1892	41,161,780	*c*264,618	156
1893	46,727,108	*a*267,569	171
1894	49,162,357	*c*270,519	182
1895	47,182,681	*a*272,667	173
1896	44,113,574	*a*274,815	161
1897	45,267,047	*c*276,963	163
1898	47,288,733	*b*277,548	170
1899	50,079,855	*b*278,133	180
1900	50,897,227	*b*278,718	183
1901	53,960,998	*a*279,293	193

a Estimated. *b* United States census. *c* Police census.

THE POTOMAC RIVER WATER.

The Potomac River, formed by the junction of its north and south branches, rises in the Allegheny Mountains, the north branch in the western part of Maryland, near the head waters of the Monongahala River, and the south branch in the State of West Virginia. These two branches, draining narrow and precipitous valleys in the mountainous regions, unite at Cumberland, Md., to form the main river, thence in a southeasterly direction, normal to its previous course and to the direction of the mountain range the river flows to the sea through one of the great estuaries of the Atlantic—Chesapeake Bay.

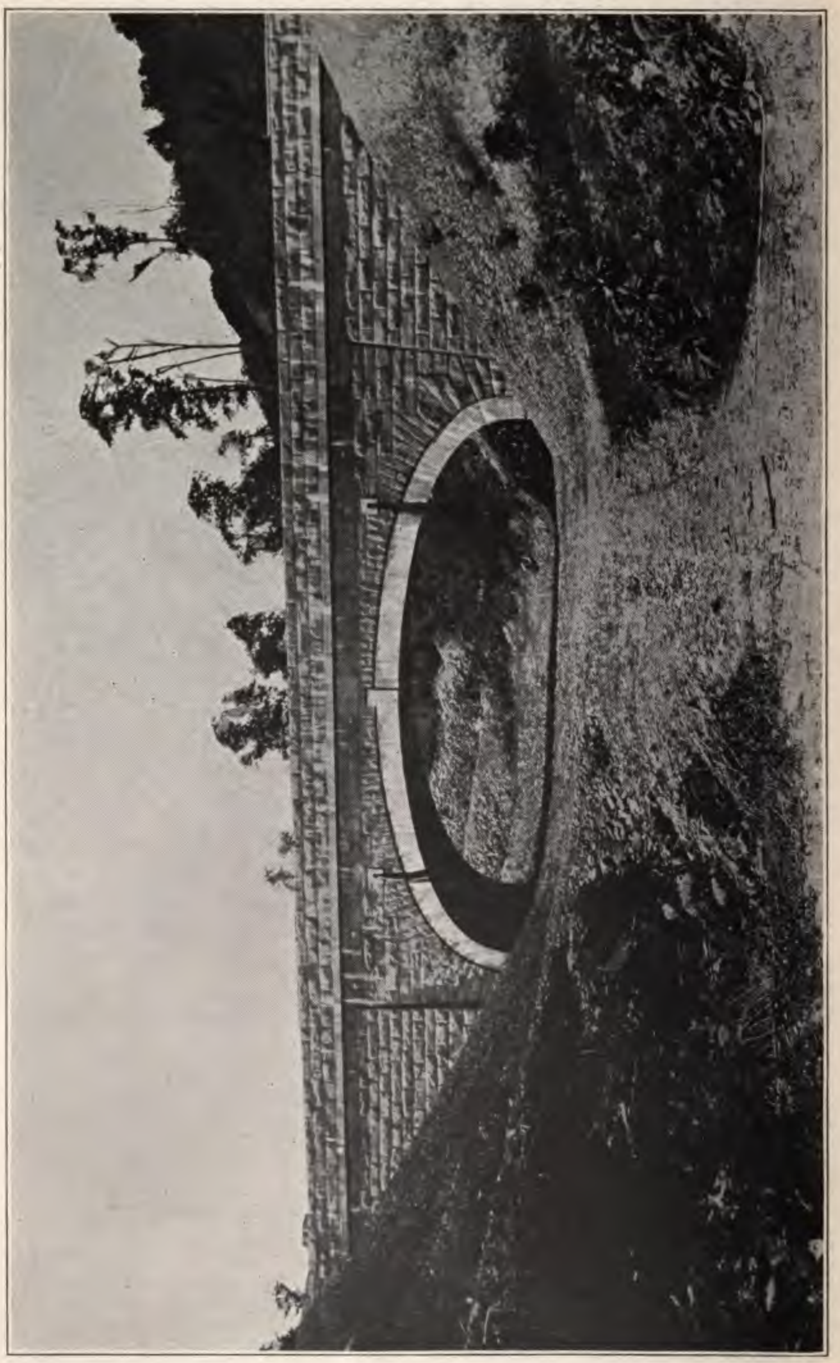
Owing to the narrow and steep-sided valleys in which it has its source and to the fact that there are no lakes throughout its basin, the Potomac is subject to sudden and heavy freshets.

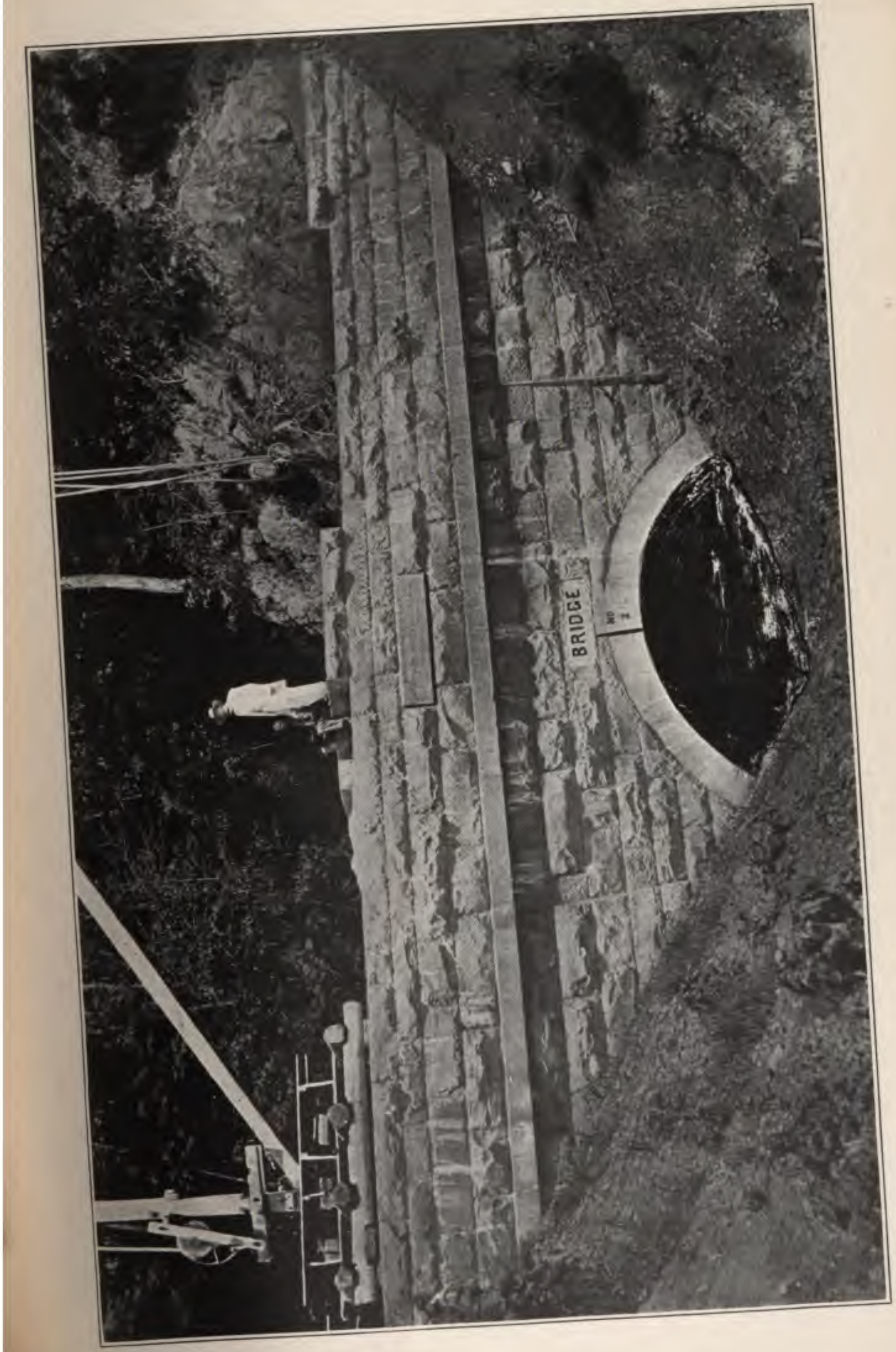
The principal tributary is the Shenandoah River, joining from the south at Harpers Ferry. Many small streams, generally from the Maryland side, are also tributary, the principal one being the Monocacy River, upon which the city of Frederick is situated. These tributaries flow through a rolling and cultivated country quite in contrast to that above Harpers Ferry.

The draininage area of the Potomac River above the Great Falls, whence is taken the Washington water supply, is 11,043 square miles. The minimum flow of the river at the Great Falls is 700,000,000 gallons per diem, or 1,065 cubic feet per second, or 0.096 cubic feet per square mile per second, the average flow 6,500,000,000 gallons per diem, or 9,889 cubic feet per second, or 0.89 cubic feet per square mile per second, and the estimated flow during the flood of 1889, 305,650,000,000 gallons, or 465,025 cubic feet per second, or 42.1 cubic feet per square mile per second. The estimated population for 1900 of the watershed is 491,813, or about 44.5 per square mile.

The towns in the drainage basin of the Potomac are not sewered, so that very little direct sewage is emptied into the stream, the main source of contamination being from surface drainage, whence may be expected pollution due to decaying vegetable and animal matter, the surface wash from fertilized fields, the excreta from man and animals, the waste from factories, and whatever salts may be held in solution derived from the natural geological formation of the basin.

From the figures given above it will be seen that the Potomac River affords an abundant supply for the District of Columbia. The present consumption—50,000,000 gallons per diem—is only about 7 per cent of the minimum discharge of 700,000,000. The present population of the




BRIDGE
No

District of Columbia is estimated as 280,000, and will, according to estimates (see report upon the sewerage of the District of Columbia, House Ex. Doc. No. 445, Fifty-first Congress, first session), probably reach 500,000 in 1930. At the present rate of consumption this population would require a per diem supply of about 100,000,000 gallons, about 15 per cent of the minimum discharge.

Pure water does not exist in nature. The rain that falls from the clouds becomes contaminated before reaching the earth. It absorbs ammonia, carbonic acid, sulphuretted hydrogen, and other gases from the atmosphere, especially in the vicinity of cities and towns. It takes up and holds in suspension floating particles of minute dust always present in the atmosphere—carbon in the form of smoke or floating soot. After falling to the earth and before it again appears at the surface as springs it has, although having undergone a natural filtration, dissolved from the soil and strata through which it has passed various soluble salts, which are sometimes so noticeable as to give a medicinal quality to the water. From the spring or fountain head the water, again starting on its journey to the ocean whence it came in vapor, is joined by other springs and surface drainage, becoming more or less polluted as the character of the districts through which it passes varies, till at last receiving the enormous sewage discharge of large cities, it becomes dangerous as a domestic supply.

The spread of many zymotic diseases is attributed by modern authorities to polluted water. It is almost universally admitted that typhoid fever, Asiatic cholera, anthrax, and even tetanus are water-borne diseases, whose germs have been carried in the water contaminated by surface drainage or sewage.

The science of bacteriology has so far advanced that careful examination of suspected water can differentiate these disease bacilli, and no source of supply should, under present conditions of civilization, be adopted for domestic purposes until this examination be made.

The bacteriological examination of a source of supply, if a running stream, subject to the various changing conditions of the seasons, should be continuous for at least a year to give perfectly satisfactory results, as the stage of the stream, the temperature, and seasons of the year all affect its condition.

In addition to the bacteriological examination, a water supply should also be submitted to a chemical analysis. By such analysis may be determined the probable source of pollution, if any exists.

The chemical analysis of potable water consists in determining the parts per million of ammonia, nitrogen as nitrites, chlorine, alkalinity, required oxygen, total solids, turbidity, color, odor and taste.

Ammonia.—The presence of ammonia in abnormal or suspicious quantity indicates pollution by animal matter, decayed or decaying.

Nitrogen as nitrites and nitrates.—The presence of nitrites is always to be looked upon with suspicion as indicating contamination. Nitrates indicate the former presence of nitrites more fully oxidized.

Chlorine.—The presence of chlorine above the normal is very suspicious. Chlorine is nearly always present in the water used for domestic purposes, due to common salt, and an excess is a positive indication of sewage contamination.

Alkalinity.—The determination of alkalinity is important as an indication of hardness. Very hard water is expensive as wasting soap, and "scales" in cooking utensils and steam boilers, and frequently renders the water disagreeable to the taste.

Required oxygen.—This determination gives a means of judging the amount of organic carbon present in the water.

Turbidity.—This is determined chemically by ascertaining the total amounts of solids in suspension.

Color.—This is determined ocularly by comparison with standards.

Odor.—This is obtained by smell.

Taste.—This is determined by physical test.

No absolute standards can be established by which a water may be condemned as unfit for domestic purposes, as the source of supply must always enter into consideration, and an excess in any item of determination may be traced to harmless causes.

The following are some of the standards quoted from Prof. William P. Mason's treatise on "Water supply:"

Ammonia.—Professor Mallet gives from an analysis of 15 drinking waters believed to be wholesome, for albuminoid ammonia, 0.125 parts per million. Dr. Leeds gives as the highest limits as a standard for American waters, free from ammonia 0.01 to 0.12 per million.

Nitrites.—Mallet gives 0.0135 per million. Leeds gives (American rivers) 0.003 per million.

Nitrates.—Mallet gives as an average of 13 samples 0.42 per million. Extremes, 0 to 1.04.

Chlorine.—Leeds gives 3 to 10 per million. Ordinary sewage contains 110 to 160 per million. Human urine contains 5,872 per million.

Hardness.—Leeds gives, in parts per million, 50 for soft and 150 for hard waters.

Total solids.—Dr. Smart, National Board of Health, 1880, gives as a safe limit 300 parts per million; to be condemned, 1,000 parts per million.

eeds gives, as a standard for American rivers, 150 to 200 parts per million.

Required oxygen.—Leeds gives 5 to 7 parts per million.

These standards are shown in tabular form:

Total solids	150.00	300.00
Free ammonia	0.01	0.12
Albuminoid ammonia	0.10	0.28
Nitrites	0.0135	0.003
Nitrates	0.00	1.04
Chlorine	3.00	10.00
Required oxygen	5.00	7.00

The following are the results, tabulated for comparison, by average, of analyses of Potomac River water:

	Total solids.	Free ammonia.	Albunin ammonia.	Nitrites.	Nitrates.	Chlorine.	Required oxygen.
Health office, District of Columbia	126.7	0.0008	0.111	Trace.	0.639	3.78	2.56
Dr. William M. Mew	125.0	Trace.	.150	Trace.	1.100	4.00	2.10
Mr. Robert Spurr Weston	139.0	.013	.105	0.002	.73	2.60	4.50
Mason's safe limit	150-300	.01-.12	.10-.28	.0135-.003	.42	3-10	5-7

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UNITED STATES ARMY.

NOTES ON
INTRENCHING TOOLS

EXTRACTS FROM "AN ESSAY ON THE TACTICAL EMPLOYMENT OF FIELD FORTIFICATION,"

By
S. PIARRON DE MONDESIR,
Chef de bataillon du génie breveté.

Translated by FIRST LIEUTENANT G. B. PILLSBURY, Corps of Engineers.

ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.,
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NOTE.

In this essay Major Mondesir advances the theory that it will be impossible for the defence to occupy the military crest of the ridge chosen as the line of defence, on account of its exposure to the artillery preparation for the infantry attack. He accordingly advocates the occupation of the military crest by small advanced parties, which he calls fighting outposts (*avant-postes de combat.*) The firing line is to intrench behind the crest of the ridge. The reserve, comprising one half the available forces, is to be concealed from the enemy, but not intrenched. The artillery of the defence is to refuse the artillery duel, but, after inflicting as much damage as possible on the first of the attacking batteries brought up, is to be posted in such positions that, while concealed from the enemy, it can nevertheless sweep with a flanking fire the slopes over which he is to advance.

As soon as the attack reaches the military crest of the position, it necessarily loses the support of its artillery. It is then to be subjected to the artillery and machine gun fire of the defence, together with the infantry fire from the intrenched firing line; and finally, at the proper moment, the reserve of the defence is to make a counter attack.

Whatever the opinions held on the system of tactics above outlined, the following extracts, relating to intrenching tools, are of interest as showing the present tendencies in the French army on this subject.

Extracts from "An Essay on the Tactical Employment of Field Fortification,"

By S. PIARRON DE MONDESIR,
Chef de bataillon du génie breveté.

[Revue du Genie, May, 1904.]

* * * * * * *

INFANTRY INTRENCHING TOOLS.

Admitting that the conditions of the infantry attack require the attacking forces to maintain their position on the conquered crests, under the artillery fire of the defence, the question of individual cover for the infantryman becomes more urgent than it was thirty years ago at Plevna. The present equipment of a company of infantry is entirely insufficient, since, of the 200 to 250 men who may have to cover themselves during the course of the attack, *twelve* only are furnished with an intrenching tool. These are just enough to dig cooking trenches, and ditches around tents.

On the defensive, the company wagon can be drawn on. It furnishes 30 intrenching tools, not even enough for a single section, if all are at work. Nevertheless, if we admit that a portion of the section are to be employed on the earthworks, while the rest are preparing the material for covering the trenches, we see that the company wagon corresponds, as far as intrenching tools go, to the *section*.

Let us suppose a battalion ordered to intrench a point of support. Dispostions are made as follows:

One platoon as fighting outposts (with *all* the portable intrenching tools of the battalion.)

One company on the firing line (with the tools in all four company wagons.)

One platoon as support (shelters to be constructed finally at a distance of 100 yards from the flanks, slightly in rear, or concealed by the terrain.)

Two companies in reserve (concealed.)

We see that the tools are sufficient, but that they are obtained at the price of disorganizing the system of equipment.

But all this applies merely to defensive operations. Now it is the offensive that should be given the first consideration.

We should be able to give every second man an intrenching spade (even if it be the present model, which is easily broken) without increasing the burden of the infantry soldier on the march. This tool would be carried on the company wagons, in place of the present reserve tools. 100 intrenching spades, without cases, with a strap to attach to the waist belt, would weigh 75 kg. [165 lbs.] We would discard 16 round shovels, 2 square shovels, 12 picks; a total weight of 75.5 kg. [167 lbs.]

It should be noted that with the modern development of the combat, the troops on the firing line are quickly exhausted, and that the same individuals do not take part in the action from beginning to end. Each element engaged that has progressed so far that it must intrench, has soon played its part, and the action must be carried forward by a new element. Accordingly the troops who have delivered the decisive attack are not those who will carry on the pursuit, or, if the attack has been checked, the renewal of the attack.

It results that the extra weight of the intrenching tool secured to the belt, distributed the moment the marching formation is changed to the formation for attack, is carried but a short time. For the assult, if necessary, they will throw away their intrenching tools. They may, indeed, throw away their knapsacks!

To this proposition, we add that of giving each squad four sand bags, or the company wagon thirty sand bags.

TOOLS FOR THE ENGINEERS.

In addition to the assistance of their hands, the engineers give the infantry the aid of their tools. Here again the distribution of the equipment, and even the tools themselves, are out of date. They are not in accord with the present tactical needs of the field of battle. They are more suited to seige work, in which case ma [illegible] r sources of supply are available (local supply, supply from the Corps engineer train.)

Two divisions are absolutely necessary.

1st division—One light wagon, two horse, per *section*. The section of engineers is the most convenient unit to unite with the infantry units in charge of the preparation of a point of support. (All theoretical studies and the experience in the non-commissioned officers schools shows this.) This wagon would carry only intrenching tools —of the light engineer model, and not the heavy reserve tools—tools for demolitions, and a small supply of melinite petards. Total, 4 wagons, 8 horses.

2d division—A wagon of the present model, 4 horse, with a lighter load (special engineer tools and the remainder of the melinite.)

This question naturally requires close study, but we maintain the *tactical necessity* for the principle of two divisions. An engineer company would see its usefulness doubled.

It should be remarked that when a element of engineers is joined to a force of infantry in the organization of a point of support, the greater part of the work (especially the trenches) would be carried on by the infantry but that there is at the same time work to be done of a character requiring the technical skill of the engineer (woods, villages, shelters, communications.) The relation between the quantity —the importance in point of time if you wish—of this kind of work, and the quantity of work given to the infantry, corresponds very often, in the concrete cases that we have studied on the ground, with the relation between the effective force of a section of engineers and of a battalion of infantry.

* * * * * * *

APPENDEX II.

ENGINEER TOOLS.

Engineers soldiers are all furnished with portable tools; the company engineer wagons and 9 heavy wagons of the Corps engineer train carry heavy model reserve tools, which would generally be handled by infantry auxillaries.

The earthwork tools (shovels and picks) of this model are handled with difficulty by men not skilled in earthwork. Again, the tactical situation, or the state of the ground, does not always permit the wagon to be brought to the spot where the tools are needed; the men are then obliged to carry the tools for a considerable distance, together with their guns and knapsacks. This is very troublesome and unpractical.

Finally, are these earthwork tools well suited to the end for which they are employed? They usually serve only for the construction of shelter trenches, of a profile analogous to the simple trench—that is to say, requiring about two hours work per running meter for an unskilled laborer.

Under these conditions, portable tools, like those carried by the engineers, would generally be sufficient for such work; being lighter, they could be carried attached to the waist belt, and with equal loads, more could be carried in the wagons.

It is of great advantage to increase the number of tools at the front. From this point of view, it would be of advantage to give each section of engineers a light wagon, carrying as many tools as the regular engineer wagon, the tools being lighter. These light wagons would be drawn by two horses. The heavy advance engineer wagons would be done away with. This would result in an economy in teams.

This disposition would give more elasticity to the employment of the company; the section, which is the true unit of work, would become independent, having always its tool wagon at its disposition.

As the number of tools with the advance would be thus increased without increasing the means of transportation, the supplies carried by the heavy wagons of the reserve train could be decreased somewhat. A number of heavy wagons loaded with heavy tools would be retained, for more important earthwork, such as the construction of approaches to military bridges.

To sum up, up to the present time our tools have been arranged for seige operations and not for field operations.

It is not a question of making a sweeping change in existing arrangements; the considerations above set forth are intended merely to indicate the direction in which the evolution of the equipment should progress, by applying the proper means to the desired end.

A. DERANCOURT.
Chef de bataillon du génie breveté.

APPENDEX III.

INFANTRY INTRENCHING TOOLS.

The portable tools of the infantry comprise spades, picks, mattocks and axes.

There are but 8 spades in each infantry company. Now the light spade is a tool for the offensive; it is the only one that enables the foot soldier to decrease his exposure in all the phases of the combat, when stationary, either by covering himself against artillery or infantry fire, or by firing behind slight cover, that he will improve with his spade.

The fight may last many hours (Saint Privat.) It is therefore necessary that the soldier should be able to intrench himself, and it would be rational to furnish each man with a light spade.

If we could have a light spade for every two men, as in Germany, it would still be a great improvement.

As, to-day, we are seeking every means to lighten the burden of the foot soldier, these light tools could be carried on the company wagon. A hundred spades would replace the 36 heavy tools that are now carried in this wagon.

When an engagement appeared probable, the tools from the wagon would be distributed to the men, just as cartridges are now distributed. This tool would be hung from the belt, so as to be always at hand.

A. DERANCOURT,
Chef de bataillon du génie breveté.

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UNITED STATES ARMY.

IMPRESSIONS *of* A COMPANY COMMANDER

By
LE CAPITAINE BREVETÉ DU GÉNIE POTEZ

Translated from *Revue du Genie Militaire*, July-August, 1901, by
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PREFACE.

The object of the present essay is not a general study comprising all the details of command, instruction and administration in an Engineer company. We desire merely to convey to our young comrades, who may be called upon to exercise the important functions of company commander, certain observations that our personal experience has suggested, and that may be of use to them in the exercise of their command.

We have been obliged to enter into a few considerations of a rather general character. At the present time, the regiments of Engineers are passing through a true period of transition. Although instruction in the "Schools" has been a thing of the past for several years, yet the instruction by company is not universally practiced. The result is that our company commanders do not always enjoy the initiative that they should have, and that some of our methods of instruction, although conforming to the regulations, may still be regarded as experimental. Thus we have been induced to discuss the conditions under which the command of an Engineer company should be exercised, as well as such modifications in the present methods of instruction should be rationally introduced.

We have deliberately left out everything that relates to the general organization of the arm. Taking the troops as they are, we have striven merely to discover the best methods to be employed with a view to their preparation for war.

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IMPRESSIONS OF A COMPANY COMMANDER.

PART I.

INTRODUCTION.

The company, troop or battery constitutes a unit of command, the effective strength of which is sufficiently small to enable its chief to know all his subordinates intimately, and at the same time sufficiently large to require that its command should be instructed to an officer whose rank and experience will enable him to regulate all the details of the command, instruction and administration of his unit.

The importance that is attached to the office of company, troop, or battery commander, even in the regulations, is thus easily understood. This applies evidently to the Engineers as well as to the other arms of the service.

What is, or rather what should be, a company commander, in a regiment of Engineers?

On mobilization, and even during the autumn maneuvers, the captains commanding Engineer companies become, for the most part, on a small scale, chiefs of seperate units. While those commanding the companies attached to army corps are subordinate to the Chief Engineers of the army corps, those commanding the divisional companies,* which are in the greater number, are directly under the orders of the Division Commander. Although the number of men under their orders is inconsiderable, yet, the salvation of the division to which they are attached, or the success of the operations, may depend on the manner in which they execute the mission intrusted to them. This will be the case, for example, when the company is charged with rapidly preparing for the passage of a stream that the division must cross, either to march upon the enemy or to escape his grasp; or, in a retreat, when it is a question of destroying some structure necessary to the enemy's pursuit. On the battlefield orders will not always arrive in time, and officers of Engineers will often be obliged to utilize, on their own responsibility, the resources at their disposal, in order to provide for the passage of a stream, to create hasty points of support, etc.

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*In each of the 20 army corps in the French Army there is a corresponding battalion of Engineers which has the same number, and which joins its army corps in case of mobilization.

This battalion furnishes one company to each division of infantry, and one company to the headquarters of the army corps.

The 4th companies of battalions would be attached to the large engineer parks of armies or be employed in the fortresses.

In time of peace the battalions of Engineers are concentrated at the regimental headquarters, which are as follows:

1st and 5th regiments, Versailles; 2d, Montpellier; 3d, Arras; 4th, Grenoble; 6th, Angers; and 7th, Avignon.

These officers should possess, therefore, in addition to a thoroughly developed professional education, a vigilant spirit of initiative, and a decision of character that will permit them to act without hesitation when the circumstances require it. These qualities are even more necessary in the Engineers than in the other branches of the service, with the exception of the cavalry; for in the other branches superior officers are at hand to rectify the mistakes committed, or to direct personally those subordinates who appear to be going wrong.

It appears evident, therefore, that the company commanders in the Engineer regiments should enjoy the greatest latitude in the command and instruction of their units. In addition to the certain benefit to the discipline and instruction of the men that results from such independence, it is unquestionably the best means of developing in the officers themselves, the spirit of initiative, decision, and professional knowledge.

If, however, we examine the facts of the case, we find that the introduction of new ideas, in regard to command and instruction, appears to be more difficult in the Engineers than elsewhere.

As regards instruction, this may result partially from the fact that, although the "School" no longer has charge of the instruction of the troops, yet there remains in the regiments, no doubt on account of tradition, a tendency to centralize excessively everything pertaining to instruction.

In the eyes of certain officers such a method in command and instruction is justified by the two following considerations:

(1) As the technical instruction necessitates the employment of

material which is common to the whole regiment, it is necessary to place the various portions of this material at the desposal of each of the companies in succession, and on this account to limit each to a stipulated time.

(2) The majority of officers of Engineers pass the greater part of their career in the special staff of the army. When they return to the regiment, they must post themselves on the methods of instruction, which may be new to them, and they must also reacquire soldierly habits. As some inexperience on their part is to be feared, it is thought necessary to maintain a close supervision over their action in the exercise of command and in the instruction of their men.

Doubtless the distribution of the material among the companies compels some restriction as to the employment of time, but it does not seem necessary to go as far as is generally done, by dividing the area of the polygon into as many "trenches" as there are different schools, and by devoting the same number of drills in each company to the same kind of work.

There are many causes which prevent all the companies from conveniently employing their time in an identical manner. One of the most frequent of these arises from periods of bad weather, which, occuring during the whole or a part of the time allowed for a "School," make a certain number of supplementary drills indispensible. It is impossible to conduct these if such a system is employed.

Again, the individual members of the company do not require the same amount of drill in the various schools of instruction. Take for example a company which has received in its contigent of recruits a number of quarrymen, excavators, or miners, who are, on account of their trade, perfectly familiar with the various kinds of earth work. As we shall show later, the training of the sapper in this kind of work must be considered as an essential part of his instruction. It is, therefore, logical to divide the company into two parts. The first will include the men who, before their enlistment, were skilled in handling the pick and shovel. It is sufficient to teach these men the posting of the workmen, the distribution of the tools, and the trace and profile of the various trenches in the regulations, and to have them throw up once or twice each style of intrenchment. The second part will include those men who have never touched a shovel or pick before their arrival in the regiment, and who must be subjected to methodical training. These will take part, of course, in the exercises of the whole company in battle formation, but the greater part of their instruction will consist of a number of progressive drills in excavation, to harden and train the muscles of the weaker and clumsier men. Those who are excavators by trade, and who would derive no benefit whatever from these exercises, will employ their time more usefully in other portions of the course of instruction. In case of necessity, they may be even employed on the details of guard and fatigue on those particular days in order to permit those that are most greatly in need of it to be present at the excavation exercises.

As each captain is best acquainted with the progress of his company in the various drills, and with the special aptitude of his subordinates, he should be required only to complete the various portions of the course of instruction within the time fixed by the commanding officer. The division of the time should be regulated by him, under the supervision of his battalion commander. Each battalion should be alloted the different classes of material, between certain dates. The battalion commander should, in turn, place various portions of this material at the disposal of captains, for stipulated periods. The number of hours that the company commanders would devote to each kind of drill would not be obligatory. There would be a limit to the time that he could devote to each, but if the men were sufficiently instructed in less time he would not be required to continue the drill for a longer period. He would in such cases report the progress of his company to the battalion commander, who would authorize him to employ the remainder of the time in drills which had been taken up previously, but in which his company was not sufficiently instructed; or, if the necessary material for such drills were not available, in field exercises, too many of which can never be conducted.

Let us now examine the argument in regard to the inexperience of the officers, and see what conclusions may be drawn from it.

It is certain that a captain returning to the regiment after eight or ten years' service in the special staff will find many changes in the drill regulations, and in technical instruction and administration. He must therefore learn many things over again and may be expected, at first, to show some hesitation in the execution of his duties.

Thus "brushing up" is necessary. It should be facilitated in every way, in order that it may be speedily and completely attained. The most efficacious means to this end, surely, is to give the officer all the initiative compatible with his position. If he makes mistakes, his superiors are at hand to correct them before grave consequences result. To restrict an officer in his responsibility and to deprive him of initiative, can only defeat the end to be attained. Such a course is no more than a palliative. It can do no more than produce a dangerous stage effect, by allowing the regiment to present a good appearance at inspection, without the training and discipline necessary for service in the field. The truly important point is to secure efficient command of the companies when the new men received at mobilization have broken the correct allignment of the barrack yard, and when they have left the orderly rooms and offices of the garrison, and are scattered in the fortifications, and in the army corps and divisions. What cohesion and discipline will these companies have if their captains have been deprived of active and full command?

Should we suppose that after they have devoted their time to a serious study of the regulations, and after they have received from their commanding officers precise but broad instructions, indicating to them the object to be attained, the time to be employed for that purpose, and if necessary the main outlines of the methods to be followed—should we suppose that the majority of Engineer officers are unequal to making excellent Engineers, capable of doing credit to their companies and regiments out of the men that the annual conscription places in their hands? The contrary is certainly the case. If from the standpoint of military routine, we have observed a few sins of omission in some who are excellent officers in other respects, such a condition results partly, no doubt, from the multiplicity of their duties, but chiefly from the fact that, during their service with their regiments, their opportunities for acting on their own responsibility have been by far too few.

We repeat therefore, that in order to develop in our Engineer company commanders both the professional knowledge and the decision of character necessary in the field, the only proper method is to give them in peace the greatest possible responsibility in the command and instruction of their companies.

More than once in this essay we shall be brought back to the fact that in time of war the majority of the company commanders of Engineer troops must, in technical matters, act on their own initiative. They must therefore, in time of peace, be trained to depend on their own resources. In our opinion this is the controlling idea which should govern their preparation for war.

Besides, it is very clear that it is out of the question to pursue a uniform course with regard to all officers. If, along with company commanders who are vigorous, intelligent and progressive, there may be found some rather below the mark, it is the duty of their immediate superiors, their battalion commanders, to guard against the disadvantages resulting from any failings in their subordinates, and, if possible, to eliminate the failings, or at least to diminish them. Thus they will guide with a tighter rein those who betray too much inexperience. They will stimulate those who err through laxity. Such is in our opinion, the essential functions of the battalion commanders of Engineer regiments, the battalions of which do not exist as war units, as they must distribute their companies on mobilization among the fortifications and the army corps and divisions.

COMMAND.

DISCIPLINE.

"Disicpline is a virtue which impels us to carry into effect the intentions of our chief, through a sense of duty and of the general welfare, by devoting to this end the whole physical, moral and intelectual energy of which we are capable."*

Discipline, as it should be understood in modern armies, seems to be very precisely defined in this sentence.

What are the means that will enable us to obtain it; and first of all, what *role*, and how much importance should be assigned to punishments?

Always more or less humiliating for those who undergo them, measures of severity can neither inspire nor develope that active devotion for one's immediate chief, which is the essence of discipline as just defined. Punishments may prevent the commission of offences, but are powerless to implant the desire to do well,—which is the essential aim of our efforts.

Punishments, in our opinion, are included for the greater part in two distinct classes, corresponding to entirely different necessities. Firstly, there are light punishments, such as extra fatigue, or one or two days' confinement, which provide a means for "breaking in" a recruit and enable us to stimulate indolent natures, inclined through laxity to neglect part of their duty. Secondly, there are the more rigorous measures, including transfer to the disciplinary companies, and trial by court martial, which are necessary in the case of those refractionary individuals who have failed to respond to all appeals to their good sentiments, and whose grave and repeated offences must be the object of stern repression.

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*"Infantry," by General Bounal.

With these exceptions, punishments may and should be reduced to a minimum, for it is very often expedient to show indulgence to men who, ordinarily perfectly amendable to discipline, have yielded to some short lived weakness.

Herein lies precisely one of the greatest means of action of the company commander, and in this connection, nothing is more detrimental than the *schedules* of punishments which commanding officers feel called upon to impose.

In such matters the tact and experience of each company commander are the best guides. We think it our duty, however, to formulate the few following remarks, which may be useful to young officers.

When one allows any offense whatsoever to pass unpunished, it is nevertheless essential to take notice of it, often by but a simple sign, without which the deliquent might think himself permitted to do the same thing again, or would conclude that his chief had not noticed it; facts which, in the long run, would be damaging to the officers authority. This observation must be made, should the case occur, in terms to make the man understand clearly, that if he is not punished, it is on account of his habitual good conduct, and because it is considered an offense that will never be repeated. Such a method applied with tact, will often contribute more than a punishment to the better discipline of the soldier, by attaching him more firmly to his chief.

The only way to obtain a faithful performance of duty is to make the men thoroughly understand what is required of them and to exercise close supervision over all details during their first days of serivce. This principle, so evidently necessary that it may appear useless to formulate it, is nevertheless very frequently neglected. Directions are given incompletely, without the superior's making sure that they have been fully understood, or are even not given at all, and the man is punished because they are unexecuted or executed badly. Or again, after orders are properly given and well understood, supervision is not exercised, men relax little by little, and at last become utterly neglectful. Punishments rain down upon the delinquents, but it is too late; the evil bent is formed, and the greatest culprits are the chiefs, who have taken no notice of the first slips, as might have been done by simple observations. This explains why the best disciplined organizations are generally those in which punishments are the least.

These considerations are of supreme importance in the training of recruits during the period immediately subsequent to their enlistment. We shall have occasion later to recur to this matter, in speaking of the arrival of young recruits in the company.

It is therefore unquestionable that punishments, considered as a necessary evil, play only a secondary part in the establishment and maintenance of discipline as it should be understood. The essential elements which contribute to discipline, correspond to three different classes of ideas.

(*a*) *The ability of both officers and soldiers*, the consciousness of which gives the man confidence in his superiors, in his comrades, and in himself.

(*b*) *Moral education*, to develop in the soldier patriotism, devotion to the flag, and the sense of duty.

(*c*) *The solicitude of the officer for the material and moral welfare of his men.*

Let us examine these in succession.

(*a*) *The ability of both officers and soldiers.*—The soldier, to be truly the instrument of his chief, must be conscious of a superiority in the latter, making him worthy in all respects of the authority with which he is vested. An inefficient officer may by the means of punishments command the obedience of his men, but will never have their confidence. Young officers should be thoroughly convinced that, by developing their professional ability, they will not only qualify themselves the better for the proper exercise of the functions of their grade, but will also greatly increase their control over their subordinates.

But it is not only the instruction of the officers that is important from this standpoint; the instruction of the men, down to the lowest private, when it is well executed, induces reciprocal confidence among all the elements of the unit. The moral worth of each individual soldier produces the same effect. From this confidence of all with regard to all, there results a firm cohesion, which forms the most invaluable of qualities for a company in the field.

From these qualities also springs the *esprit de corps*, an excellent thing in itself, provided that it be not exaggerated, and that the consciousness of the merits of one's own arm be not combined with a scorn for all others. The consequences of such a condition may be, as is unfortunately sometimes the case, that soldiers who are entirely devoted to their own officers show themselves much less disciplined when they are placed, either alone or in small parties, under the orders of officers of other arms.

The comradeship of arms, which within a few years has made such great progress in our corps of officers, should, to receive its full development, extend to the men. Even more, perhaps, than for the soldier of other arms, this quality is necessary for Engineers, summoned as they often are, in small detachments, to aid troops of other arms. Moral education, tending to develop in the man the most lofty sentiments, pemit us to impress upon the soldier the necessity for mutual devotion in all ranks of the army; and from this point of view its most useful complement will be found in grand and garrison maneuvres, and in general in all opportunities which should be made as numerous as possible, for combined operations of Engineer troops with detachments of other arms.

(*b*) *Moral education.*—The daily routine of duty furnishes the captain with the means of acting, to a certain extent, upon the moral well-being of his subordinates. But this educational function should not be confined to these limits. It is not enough, indeed to limber and strengthen the body of the soldier; to teach him to handle the arms and tools he will use in war; to obtain precision in the execution of the daily routine in time of peace; it is also and especially necessary, as far as the nature of each individual will admit, to develop in him moral qualities of the very highest order, the absolute devotion to the fatherland and to his flag, and the spirit of abnegation which impels the soldier to sacrifice his life without hesitation when the interests of his country require.

To this end the captain will assemble the whole company from time to time, and will endeavor to impress upon his men the nature and importance of their duty to their country. Some officers hesitate to do this, believing that they are not gifted with sufficient fluency of speech. Let such men lay aside all apprehension. It is not a question of delivering a philosophical dissertation, for this would be incomprehensible to a majority of the men. In the midst of Europe in arms, the necessity, more imperative than ever at the present day, for the complete devotion of every Frenchmen to his country should be briefly discussed, and an elementary history of France, and especially of our own times, should be given to the soldier,—facts which will indicate our probable enemies, which will remind him how Germany prepared and conducted the War of 1870, and which will impress upon him the obligation for all Frenchmen, if they are unwilling to fall into decadence, to reëstablish some day the integrity of the territory of the fatherland.

No abstractions should be indulged in during these familiar conversations; the anniversary of a battle taken part in by the company, an act of devotion performed by some soldier of the regiment, in a general way every incident supplying a theme for an excursion which may touch the heart and imagination of the soldier, will give the captain opportunity for a brief discussion, in which the lesson or example to be drawn by each man will be made plain. It is not necessary to be an orator to do this. In such matters the officer has only to let his heart speak; this will be his surest way of touching the hearts of his men. Let those officers try it who have not thought it their duty hitherto to employ this method of education. To be convinced of its efficacy, it will be enough to see the faces of the men listening to their captain, when he is explaining one of those questions which mean life or death, or at least incontestable greatness or a irreparable decadence, to a great nation like France.

(*c*) *The material and moral welfare of the soldier.*—The regulations prescribe that all officers, of all grades whatsoever, shall take the most solicitious concern in everything connected with the material needs of the soldier. In the absence of any other reason, these instructions would be justified by the evident fact that the physical effort that may be demanded of the man, and his resistance to all kinds of fatigue, bear a direct ratio to the extent to which the body is maintained in vigor and health. But this material result is not the only one obtained by an officer truly anxious for the welfare of his subordinates. It is clear, indeed, that since the physical reacts upon the moral being, the later will be so much the better for the soldier's more vigorous and healthy condition; but there is another consequence equally deserving our attention. The feeling that his chief is concerned in his welfare exerts an excellent influence on the man's state of mind; nothing is more depressing to a company on the contrary than to perceive that its commanding officer lacks interest in its material needs.

The moral welfare of the soldier demands equally our care. To make the recruit, unaccustomed to the new element in which he has to live, feel on all sides the sympathy of his chiefs and of his comrades; to take care that the non-commissioned officers show moderation as well as firmness in the exercise of their authority; to repress extravagant language and harsh words, which merely irritate the victims against their superiors; and in general, to spare the soldier every useless shock—all these contribute to the establishment of good discipline, and ensure the officers not only the respect and obedience, but also the sympathy of their subordinates. A mark of solicitude, a cheap attention for the officer who gives it, often ensures the deep attachment of the soldier concerned, during his whole service, and in years to come. It may be a favor to a man on the way to a sick parent, a visit to the hospital or to the infirmary, or even less, some mere trifle, but to the soldier it is proof that his chief takes an interest in him.

OFFICERS.

A very interesting and sometimes a very delicate part of the functions of the company commander is his conduct toward his subaltern officers.

A young officer graduates from Fontainebleau or Versailles; he joins the regiment with a good theoretical education, but is lacking the practical part of his profession. In order to become a good company officer, with all the authority that comes from sterling professional merit and a profound knowledge of men, he has much experience to gain. The importance, therefore, of his first impressions and the great influence of his first immediate chief, his first company commander, may be readily conceived. The greatest concern for his lieutenants, and particularly for the recent graduates, the first steps of whose official career he should guide with all possible solicitude and tact, should therefore be an essential duty of the captain.

Doubtless the captain is not and should not be the only officer to direct and instruct the lieutenants under him; the field officers and the colonel especially, participate to a great and even a preponderating extent. We often hear, "Like colonel, like regiment," which amounts to saying, from our present point of view "Like colonel, like corps of officers." Now the young lieutenant is easily affected by the new environment in which he is called to live. But although thus limited, the captain's task is important enough to demand his care.

We have striven to prove that the greatest initiative possible should be left to the company commander; the same principle will guide this officer in his dealings with his subordinates and especially with his lieutenants.

Of course the degree of initiative left to the latter should be carefully proportioned to their degree of experience; however, unless the incompetency of an officer is apparent, a company commander should be guided by the two following rules:

(*a*) To reduce orders and instructions to the least strictly necessary, and for this reason, never to prescribe details that can be regulated by a lieutenant.

(*b*) Orders once given, to interfere in the execution thereof only if he foresees that the subordinate will fail to accomplish his object. If the result of the first measures taken will be merely a waste of time or some similiar inconvenience, the captain should allow him to continue the course adopted. When the work or exercise is finished, he will explain to the officer that another method would have effected a saving of time, of personnel or material. The lesson will thus be much more profitable.

This rule does not apply, of course, when the company is taking part in combined maneuvers.

When the captain makes a decision of importance in regard to the discipline, instruction, or administration of the company, it will generally be advantageous to acquaint his lieutenants with the reasons which have influenced him in making it. By taking this course, not only will he qualify them for their service as company commanders, but he will post them thoroughly as to his views on various matters of duty. In this way he obtains the invaluable result that, if he is absent or not available, these officers will act, if not exactly as he himself would have acted, at least in a manner generally conformable to his intentions.

The performance of duty is more precise and enthusiastic as it is easier and more agreeable, and a captain who endeavors to spare his lieutenants useless drudgery may on this account be more exacting in the various duties that result in useful ends.

We may add, that a captain really worthy of the functions devolving upon him will find it profitable to treat his subalterns as comrades. The captains who keep their lieutenants at a distance are often officers, who, conscious of their inferiority, fear to compromise their authority by allowing their subordinates to become too well acquainted with them. Such captains are only to be pitied; but those who for any other reason think it their duty to act in such a manner will surely gain by changing their methods. If their subordinates are taken further into their confidence, they will acquire more assurance in the routine of duty; the ideas and intentions of the chief being well known to all, duties will be performed more readily, without any of the friction that too frequently occurs in the units where cohesion is lacking, because the chiefs have been unable to establish unrestrained relations with their subordinates.

It is hardly necessary to say that the captain's good example, the most scrupulous precision on his part in the performance of every duty, is the best means at his disposal to impress the sense of duty vividly upon his young subalterns.

The instruction proper, of his lieutenants, should consist almost entirely of practical exercises, and the daily routine is from this stand-point the best of schools. There is, however, a portion of this instruction to which we think we should draw attention, for it is generally, in our opinion, not sufficiently developed. This is a knowledge of other arms and of general tactics. Everybody agrees that whether an officer belongs to the infantry, cavalry, artillery or Engineers, he is but half formed if he is insufficiently acquainted with the other arms. This knowledge is required on account of the aid that the various elements of the army should give each other on the battlefield.

It must be observed that, except in the rare cases where they are utilized as infantry, the mission of Engineer troops in battle always consists in preparing or facilitating the action of one or several of the other arms. On the other hand, during an action, as we shall see later in speaking of technical instruction, Engineer officers should be at all times able to grasp the situation, in order to seize without hesitation the opportunities that enable them to employ, on their own initiative, the personnel under their orders. We may conclude from these two considerations, especially if we bear in mind that no intermediary exists between the division commander and the captain of the divisional Engineer company, that, of all arms, the Engineers stand most in need of thorough instruction, both as regards tactics in general, and the special tactics of each arm and particularly of the infantry and artillery.

Besides, if we may judge from what happens ordinarily during grand maneuvers, the captain of the divisional company will as a rule accompany the division commander in the field, and the company may be left in command of a low ranking lieutenant. This will cause no great trouble as long as the company has nothing to do but to march in its place in the column. But if an action becomes imminent, and the captain has been sent on a reconnaissance or is prevented by some other reason from immediately rejoining his company, the task of guiding the company in the midst of troops of all arms, and of making important decisions on points that come up from time to time, will fall on the lieutenant.

One can not, therefore, begin too soon to develop practically, as far as possible, the tactical instruction of young officers. Reconnaissances, exercises on the map with both sides represented, maneuvers of all sorts, will, for this reason be of the greatest profit to them.

THE NON-COMMISSIONED OFFICERS.

The part played by the sergeants of a company is of great importance. They are the indispensable auxiliaries of the officers in all the details of military duty, and its proper execution is thus dependent, in great part, on their efficiency.

In permanent contact with the men, they exercise an immediate influence over them; their *esprit de corps*, and their manner of performing their duty, has consequently, a considerable effect on the company as a whole, and the greatest care of the captain should be to have a good body of non-commissioned officers. The adoption of the three-year service, by bringing about a much more frequent renewal of this grade, has rendered the task of the company commander much more difficult. Formerly, when the five-year service was in force, each year, at the release of a class, about one-third of the non-coms were lost. Those who remained maintained the traditions, and the newly promoted men formed themselves, so to speak, on their older comrades. It is no longer the same. Each year, in September, the companies have their staff of sergeants entirely renewed, with the exception of the first sergeant and one, or rarely, two reenlisted sergeants, with also possibly a sergeant who was not discharged, having been promoted to this grade before two years service, or one from the men enlisted for four years. The sergeants coming under these last two heads are not numerous in Engineer regiments. The new sergeants are imbued with a spirit and bring into the company habits which are not those of their new surroundings. This system brings about critical periods which should demand all the attention of the captain.

One way of reducing this inconvenience, is to require that a man who has served in the company as a corporal be assigned to it as a sergeant. By taking care in the selection, one will thus have, with the reenlisted men who generally remain, a nucleus that will greatly facilitate the breaking in of the newly promoted men from other companies.

It is also very advantageous in this connection—but this is the colonel's business—to see that the vacancies among the sergeants which are produced at the release of the class, are not all filled at once; but by means of two seperate promotions, one at the end of September, the other a few days before the arrival of the recruits.

Upon receiving his new sergeants, the captain should explain clearly the way in which he desires their duties performed. It is erroneous to believe that the regulations indicate the duties of each grade so clearly as to dispense with this. The young sergeants need a guide. It is also clear, that in a company, all those who exercise any authority whatever, should do so in conformity with the views of the captain, and it would be improper, from this standpoint, to leave the new sergeants to their own devices.

It is especially necessary to make them understand properly, from the day of their arrival in the company, that the actual execution of the details of the military duty rests almost exclusively on them, and to inspire in them the greatest horror of lying, a vice unworthy of a soldier whatever his grade, and one to be combatted by every possible means. In return they should be shown such confidence as will raise them in their own estimation. They will thus acquire, of themselves, the habit of doing their duty conscientiously even in the absence of their officers, and under circumstances which render the detection of wrong-doing impossible. A few remarks of interest, properly shown, will succeed in making of the new sergeants subordinates who are entirely devoted to their captain. Let there be added to this a discreet supervision, at first, of the details of their duties and a firm yet kindly correction of the usual trifling failings; and you will have at the end of two or three months sergeants who, with few exceptions, will be entirely competent in the performance of the duties which have devolved upon them, and valuable assistants to their officers.

Officers will, of course, never intrude upon the just authority of their sergeants. The attention of the lieutenants should be specially called to this point. On the contrary, in proportion as they acquire experience, the sergeants will be left more and more to themselves and will be intrusted with tasks a little beyond those which properly belong to their grade; the double advantage will thus be obtained of giving them greater prestige in the eyes of the company and preparing them to replace their officers in case of need.

It must be recognized that many captains who complain of the inefficiency of their sergeants have only to examine their own consciences. If they had not neglected the instruction of the sergeants at first, and had not waited until the effects of the bad habits were felt before interfering to correct them, but, on the contrary, had seized every occasion to develop the self-reliance and initiative of these men, they would find that their indifferent sergeants would have made very fit non-commissioned officers. Their restricted length of service does not certainly facilitate the task of the company commander, but this is the more reason for devoting every care to it. The way in which the sergeants perform their duties depends upon the manner in which they have been brought up by their captain; and it may truly be said that the quality of the sergeants of a company and the spirit which animates them is the true test of the ability of the officer in command.

THE CORPORALS.

Although low in rank, the grade of corporal is none the less one of the most difficult to fill properly. The corporal has not had ordinarily, enough experience, to teach it to his subordinates. The life in common with the latter leads almost necessarily to a familiarity that is not conducive to increasing his authority. It may even be said that a corporal depends, to a certain extent, on the men of his squad, for, as his duties are numerous, he is often obliged to appeal to their good-will to prepare his accoutrements, clean his arms, etc. In addition it sometimes unfortunately happens that the corporal may get into difficulty with the sergeants, and may find that instead of aiding him in the performance of his duty they are shouldering on him a part of theirs. One may easily appreciate, therefore, how thankless the duties of the corporal may be. In some cases his duties are laborious; he is responsible to many superiors, and, in spite of his best efforts, he does not succeed in satisfying all.

The captain has, therefore, many reasons for being very solicitious in regard to his corporals. He should aid them in their inexperience by his advice, supervise as closely as possible the discipline of the squads, and facilitate them in the performance of their duties as far as lies in his power. As almost all of them are destined to become sergeants, he will attach the greatest importance to their military and technical training.

This question of promotion from the lower grades leads us to say a word concerning the special "platoons of instruction" which are still in use in the Engineer regiments. A few days after joining, the recruits are examined in the companies with regard to primary instruction, where they are given a dictation exercise and two or three problems; those who come out the best are nominated for the "platoon of special instructon." We may remark that this assignment is made solely in accordance with the results of the primary examination as the men have been in the service too short a time for their captain to be able to appreciate them from any other standpoint.

From this time on they are practically out of the company. If, in some cases, their theoretical training may be improved by this course of instruction, their practical and military training certainly suffers.

Those who are not extraordinarily awkward at drill, or of notoriously bad conduct, or who have not a particularly poor memory complete the course in the instructional platoon without mishap. Each is then given his relative number, depending principally on the facility with which he has learned the "letter of the theory."

With rare exceptions, promotions of the "candidates" to the grade of corporal are made in the order of their arrangement in the platoon of instruction.

The result of this system is that the candidates are selected for instruction, classified in the platoon, and finally promoted, all according to their facility in memorizing theoretical instruction. We need not point out the fact that such a system is not the one to secure practical results.

What precedes, applies to the instructional platoon of the candidates for corporals. The same difficulties are found in that of the lance sergeants; with this extenuation however, that as the non-coms who form part of it have had some service, it is possible to know more of their militiary qualities. Nevertheless, here again memory plays the principal part. The conclusion must be reached that the candidates for corporals and sergeants should be instructed with their companies in the same manner as the other men. There is, besides, no reason why the system that is recognized by the most competent military authorities as the best for infantry should not also be best for the Engineers. Last of all, it may be stated that we have never seen instructional platoons organized except for military instruction, properly so called, everything that relates to technical works being taught in the company to all the men whether they are, or are not to receive advancement.

The almost necessary result of instructing candidates for corporals and sergeants in their own company is that they are promoted in their own organization. It has been said that the result of this course

a personal knowledge of his recruits as soon as possible after they join.

For this purpose, immediately on their arrival he will look them over individually, will question them concerning their occupations in civil life, the condition of their family, etc., and will carefully enter all this information in a note-book, to which other information may be added later, as he knows them better. This book will furnish data that the company commander will find useful in many circumstances, such as applications for leaves of absence requested because the soldier must support his family, must be present at harvesting, etc.

This method of procedure is advantageous from another point of view. The recruit sees in it the interest that his captain takes in him, and from the beginning, does not look upon him as a stranger. This feeling stimulates his good-will and suppresses any feeling of apprehension that would interfere with his usefulness.

We may sum up these remarks, therefore, by stating that the duties of the captain should be exercised with great firmness, care, and kindness.

Details vary, and should vary with the chief who employs them as well as with the men to whom they are applied; and the method which succeeds in one case may not be suitable in another. We need not consider the three attributes above indicated as any the less necessary. The individual temperament of each captain will merely give predominance to one, without ever allowing him to suppress any of the three completely, if he desires to be sure of obtaining everywhere, and under all circumstances, the best possible result from the men the country has entrusted to him.

PART II.

INSTRUCTION.

All officers who, during the past few years, have been engaged in the instruction of Engineer troops, can testify how difficult, not to say how impossible, it sometimes is to give sufficient time to each of the different branches, both military and technical, which make up this instruction. Such a situation is due to several causes, to remove which is not within the sphere of the company commanders; they can only endeavor, by increased zeal and activity, to diminish the resulting ill effects.

However, on account of the extreme importance of this question, and although it is but indirectly related to the chief object of our paper, we have thought best to set forth certain considerations, which for the sake of clearness we have relegated to an appendix at the end of the present essay. We shall then confine ourselves in the following chapter to a few remarks, which seem to us likely to be of interest to our young comrades entrusted with the command of companies.

Since the point to be determined is the relative importance to be given to a branch of instruction or to some part of it, we must suppose that the company commanders are left free, as far as practicable, to regulate for themselves the employment of the time, under the supervision of the battalion commander. They will be governed by the two following conditions:

(1) To finish the different parts of the course at the times fixed by the commanding officer.

(2) To have the company ready for service as soon after the recruits have joined as is possible.

MILITARY INSTRUCTION.

DRILL REGULATIONS.

Existing orders provide that the infantry drill regulations apply to Engineer troops. It is quite certain however, that the latter, by reason of the exigencies of their special instruction, cannot study or practice these regulations to the same extent as the arm for which they are more particularly intended. This besides, would be useless, for when in rare cases Engineers are employed as infantry, they are so employed under very special conditions which do not require in the Engineer soldier all the qualities that a good infantryman should possess.

For the details of this instruction we cannot do better than refer our comrades to the remarkable work of General Bonnal. Of course, we must take into consideration the fact that it is almost impossible for Engineer troops to engage in certain exercises, such as boxing and single-stick, which doubtless would be to their profit, but which must yield precedence to other branches of instruction much more important to the Engineer arm. However, we must avoid falling into exaggerated ideas, and considering everything in the way of gymnastics to be useless to the Engineer. Running and jumping, in particular, might be practiced to a greater extent than is usually the case.

The necessity of recurring frequently to individual instruction and to exercises in detail is perhaps greater in the Engineers than in any other arm. The goings and comings on the engineer drill ground, where it is impossible to exact absolute and continual correctness from men often burdened with the most various loads, rapidly gives to the men, if one does not look out for it, a habit of carelessness most prejudicial to the proper execution of movements when close formations are resumed. It is then indispensable, over and above the drills properly so called, to take the men in hand whenever the occasion arises.

FIELD DUTIES.

In the instruction in field exercises, the dispositions which must be taken by a company or smaller detachment to protect itself when acting alone, must frequently be studied. The case of the company employed as a unit in a complete system of outposts must indeed be regarded as quite abnormal, while a detachment of Engineers may often be required to provide for its own security in cantonment or bivouac, when with a special mission in view, it is employed in front or on the flank of the army, covered at most by a few small bodies of cavalry.

As regards the assembly, it is essential that the company be well trained to form in the minimum time without drum or bugle. A company of Engineers is in camp in a locality also occupied by bodies of other arms. In the middle of the night its commander receives orders to set out immediately with his company to make a demolition, repair a crossing, etc. The company or the detachment must, in this case, be able to assemble rapidly, and to do this in silence so as to disturb in no way the rest of the other troops. To this end the sentinels will make themselves familiar with the quarters of the officers and the non-commissioned officers, so as to be able to waken them in the night without any groping about. The sergeants for their part, will know exactly where the chiefs of squads sleep, and the latter the sleeping places of their men. In drills of this nature the non-commissioned officers must be trained to arrive at the place of assembly with their half-sections or squads complete; and must be made to understand that a sergeant or corporal does not fully perform his duty in reporting to the captain the absence of such or such a man; he must first have done everything in his power to find the man. Whenever the company is required to pass the night out of barracks these measures will be strictly enforced, so that everyone may become thoroughly accustomed to them.

MARCHING.

The Engineers must be as well trained in marching as the infantry. They must always keep up with the infantry columns to which they are attached, and must sometimes be able to make twice the distance of an ordinary march, and still arrive in a condition to begin work.

This training cannot be obtained by means of marches performed once a week, or once a forthnight. Such exercises, so spaced, will only enable a previously trained company to keep in marching trim.

To accomplish the desired result, the company should make, consecutively—excepting necessary days of rest—eight or ten marches of increasing length. Two weeks may be given to this purpose, which will be utilized in the following manner:

FIRST WEEK.	SECOND WEEK.
Monday, 15 km. (9 miles.)	Monday, 22 km. (14 miles.)
Tuesday, 18 km. (11 miles.)	Tuesday, 25 km. (16 miles.)
Wednesday, rest.	Wednesday, 25 km. (16 miles.)
Thursday, 18 km. (11 miles.)	Thursday, rest.
Friday, 20 km. (12 miles.)	Friday, 30 km. (19 miles.)
Saturday, 22 km. (14 miles.)	Saturday, 35 km. (22 miles.)
Sunday, rest.	Sunday, resst.

These practice marches are preferably made at the end of winter, between the end of recruit instruction and the beginning of the season on the engineer drill-ground. At this time the young soldiers are under better control than at any other, and consequently no time is more favorable for accustoming the company to march in the best order compatible with the condition of the road and the state of the weather. This instruction is of the greatest importance, and it may be said that the appearance of a company on the march when it has just made 30 km. in bad weather or over a cut-up road, is one of the best criterions of its instruction, and even of its morale.

Taking this view, some officers advocate the use of the cadenced step; and in certain army corps the route step has been forbidden except in crossing fields. There has been considerable discussion on this question. While the cadenced step gives a fine appearance to the company on the march, and permits distances to be exactly maintained, yet it causes great fatigue to men of exceptional conformation, in all cases, and to the whole company on roads that are not perfectly smooth.

On the other hand, it will be observed that after a few consecutive marches the men at a route step will plant their feet—the right or left indifferently—at very nearly the same time. This no doubt results from the fact that, as they are accustomed to the cadenced step they have a tendency to plant their feet at the familiar tread of the company. As a consequence of this fact, each man, in order to march more easily, takes the step from the man in front of him. It may be said that after three or four consecutive marches, the company at route step will take a step that differs from the cadenced step only in the fact that it changes from section to section, and even in the sections themselves. These changes are the result of the small breaks caused by trifling irregularities in the road, on account of which one sees the men change step frequently when marching at the cadenced step.

We may therefore conclude that while there are objections to employing the cadenced step for the whole company, and imposing it on all the men, yet it is most advantageous to require the sections to march in cadence, with the understanding that the men who cannot conform to the step without fatigue shall be permitted to take the route step. Under these conditions the cadenced step, far from being an inconvenience to the soldier, facilitates the march, and permits as far as possible the preservation of the alignment by ranks and files, which must be observed whenever the state of the road does not require that the men be allowed to choose at will the best paths, or the temperature does not necessitate increased intervals.

If the guide takes a regular step, and if he is careful not to increase the gait on descents, nor to decrease it on ascents, we reduce to a minimum the lengthening out of the column and the resulting fluctuations. These fluctuations are the most fatiguing element of a march over good roads in ordinary temperatures.

We must remark on the advisability of conducting these field exercises by company, and not by battalion, or by regiment, as is sometimes done. Except for the very rare cases when the three companies of an army corps are united for some special duty, the Engineer troops in campaign will operate by companies. It is essential that the captains become accustomed to acting on their own responsibility, without other instructions than the very general ones which will be received from their immediate superior authorities, and to regulating without hesitation a number of details which, in an infantry regiment, fall to the colonel or the major.

TARGET PRACTICE.

Without having the same importance as for infantry, target practice nevertheless constitutes one of the essential portions of the instruction of Engineer troops.

It must first be observed that in the instruction of the marksman, whether he be an Engineer or infantryman, two very distinct objects are contemplated:

1st. To teach the man skill at target practice,—in other words, to make him a good shot on the range.

2d. By frequently repeated drills, to so accustom him to the motions of loading and aiming, that they become instinctive, and are correctly executed even at short range, in spite of the excitement caused by the proximity of the enemy. It is certain, indeed, that as the distance between the hostile forces diminishes, the number of men who are really in condition to take careful aim becomes less and less; at the moment for decisive fire action, all that can be expected of them is to shoot into the crowd.

Is one justified then in saying that skill in target practice is useless? Certainly not. The infantry especially, in order to embarrass the service of the hostile batteries, may have need of carefully aimed fire, delivered from such a range that the excitment experienced by the best shots, who will be employed in such a case, will have little effect on their marksmanship. Again, on the defensive, when fire is opened at long range, many men will be able to use the skill which they have acquired at target practice. But there is another reason which by itself would justify the importance usually attached to target practice, and this is that when a man shoots well, he acquires a confidence in his weapon that gives him confidence in himself.

As regards Engineer troops, it is to be observed that they will fire only when they are immediately threatened by the enemy, or in an emergency in default of infantry. It would seem that the Engineers will seldom fire at long ranges, such as 800 to 1,000 meters; but that their fire will be limited to short ranges.

It is therefore important, for the reasons given, to have them execute frequently the motions of loading and firing. To this end, every time that the company, for any reason whatever, falls in under arms, it should be put through the motions of a few volleys and of firing at will. In any case, these exercises, which take up very little time, should be conducted not less than three times per week.

As to target practice, the course laid down in the firing regulations, when properly applied, gives most of the men sufficient skill in this direction. However, it is usually found that some of the men are far from proficient after considerable practice. In some cases this results from defective vision, which must be corrected by suitable glasses. In others it is caused by the men jerking their shoulders, or fingers, as is indicated in Article IV of the firing regulations. The regulations prescribe the means for remedying such defects. But the most frequent cause for the poor shooting is that the arms or eyes of the men are fatigued before they have succeeded in directing the line of sight on the object. It is then impossible for them to take proper aim, try as they will, and in despair of success they pull the trigger almost at random. It is obvious what the result of such firing must be. For such men, the majority of the bad shots, there is a simple and effective remedy. It is a method used by many good shots to improve their aim. It consists merely in practicing a few minutes each day in aiming at any definite object, and holding the sights on the mark as long as possible. After a few days of this practice a great improvement will be noticed, even in men who previously could not hit the target at all.

In addition to the instruction of the men, there is the instruction of the officers. For the infantry at least, this is the more important of the two. It comprises the estimation of distances, the employment of different kinds of fire, and the regulation and control of the firing. As Engineer troops will nearly always fire at short ranges, the instruction of Engineer officers in fire control is much simplified.

It must not be concluded, however, that this instruction may be completely neglected.

TECHNICAL INSTRUCTION.

As regards the details of instruction in sapping, mining, and bridge building, we have no remarks to make; we shall only say a few words on the fortification of the battle-field and on technical instruction in winter.

'FORTIFICATION OF THE BATTLEFIELD.

Field works may be divided into two distinct classes; the first includes the more or less deliberate works, constructed in the mere presence of the enemy, in the organization of an important defensive position; the second includes those that must be executed with the utmost rapidity—sometimes in a few minutes—under the pressure of an imminent attack. Examples of the latter class are the organization of a point of support just occupied by the advance guard, or clearing a road for a column about to attack, etc.

The construction of works of the first class can always be accomplished by ordinary laborers, if they are relieved sufficiently often. Those of the second class, on the contrary, must be rapidly laid out, quickly commenced, and vigorously prosecuted. This can be accomplished only by specially trained troops.

In the first class of works, therefore, the working parties should be drawn from the infantry, except for those portions of the work for the execution of which the trained personnel or the special equipment of Engineer troops is necessary. Such a disposition is, moreover, usually unavoidable, for there are not enough Engineer troops to completely prepare the defensive positions for a large force. It would even appear preferable to spare the Engineers in such work, in order to avoid exhausting their energy before the battle begins, and to save them for the many tasks that fall to them after it has begun.

When the battle has commenced—and especially if the action is an offensive one—the infantry will have other things to do. They will be on the firing line, or massed for an attack, or maneuvering for their positions on the battlefield. The work that circumstances from time to time require, in the course of the action, will fall almost exclusively on the Engineers. The companies with corps headquarters will be charged with the work of general importance to the army corps, such as the preparation of positions for a retreat, the destruction of important structures, etc. The divisional companies, closely accompanying the infantry, will have to fortify the points of support seized by the advance guard, and those which the infantry takes possession of in the preliminary combat; open roads to facilitate the movements of infantry and artillery; and execute the other work required on the field of battle.

Above all, it will be in case of an attack from an unexpected quarter that the greatest efforts will be required of the Engineer troops. If these are well trained and well commanded, they may in a few minutes organize a point of support which, weak as it may be, will perhaps enable the few men on the ground to gain the necessary time for bringing up the reserves. The captains must usually in such cases act on their own responsibility, without waiting orders, which if they come at all, will almost always come too late.

In order that this duty may be properly preformed, Engineer officers should be, as far as possible, informed of the intentions of the Commanding General. They must attentively follow the phases of the combat, and should be sufficiently versed in tactics to understand the situations that successively present themselves. They should possess the initiative to unhesitatingly adopt on their own responsibility the measures that the circumstances require. Finally they should have the professional training to make the best use in the least time of the resources at their disposal.

As regards the enlisted men, they must be well trained in earth work, both in order that they may do the work rapidly, and also that they may have the endurance to repeat this effort several times in the course of a day. It is very necessary that they be trained in rapidly commencing a field work. While an officer is tracing the work, the men should be receiving their tools. They are then rapidly posted and immediately begin work. They must be taught, in proper cases, to modify the regular profiles, so as to get the necessary earth with the least labor, the only dimension of the parapet that cannot be deviated from being the thickness of the parapet, which should not be reduced below 80 cm. (30 inches). Under this system of instruction, the results obtained with a well drilled company are surprising.

THE WINTER SEASON.

A few years ago, the interval between the date that the new soldier joined and the end of March, was devoted only to their military instruction. It now includes a number of technical drills (about two per week) intended to give the recruit some notion of the special duties of the arm, with a view to the possibilities of a mobilization in the spring. We thus have at our disposal thirty drills, and must determine what use to make of them.

The most apparent solution is to divide the time between the different branches of instruction in proportion to the total number of drills which each would require in the course of a year; in order to give each recruit some facility in performing all the tasks which may fall to an Engineer soldier in the course of a campaign.

But such a result appears very difficult to attain. It can scarcely be assumed, for example, that a young recruit who has attended two or three boat drills in the Arras bridge school, can fill his place in the anchor and boat detachment of a company throwing a ponton bridge over the Rhine, or even over a much less rapid stream.

It does not appear, however, that the attainment of this result is indispensable. The essential thing is to have all the companies constantly ready for mobilization—that is to say, in a condition to execute all the work that may fall to an Engineer company in the course of a campaign. If they cannot be constantly ready for mobilization, every effort should be made to reduce as far as possible the period during which they are not ready.

Let us take for example the ponton drill, and consider the case of a company whose recruits have two or three months service. We leave out the sergeants and corporals, who, if they have been well instructed, should be ready to perform all the duties of their grade.

Let us suppose that a mobilization occurs, and that the company mobilizes on its peace footing, 80 enlisted men, of whom 40 are recruits. What instruction should the latter have received in order that the company may build, under normal conditions, a bridge by successive pontons, without the assistance of the reservists?

Among the 40 old soldiers, the 20 best instructed in boat drill will be selected to form the anchor and boat detachment; the 20 others will compose the lashing detachment. The new soldiers should be competent to build the abutments, place the side rails, and, with a few auxiliaries, carry the balk and chess.

They may, besides, receive the necessary instruction for such work on any pond or water-course, the swiftness of the current having, in respect to this, no importance. It will likewise be advantageous to drill a certain number of them in lashing, in order to provide for a possible shortage in the old soldiers, who should in every case furnish the anchor and boat detachment complete.

Therefore, to confine ourselves to this one example, we may ask whether to prepare Engineer troops for war, it would not be better to teach each man thoroughly a portion only of the course of instruction, that he may fill a few specified positions, instead of instructing all the recruits uniformily during the winter season, with a view to giving them all a smattering of all their duties. The instruction of the men may be completed during the summer season, by taking them successively through all the duties.

Carrying out the same idea, it does not appear necessary to give to the new soldiers, during the winter, any information on the use of explosives. The company should always have a sufficient number of trained men to execute such work.

There are some drills, however, in which every enlisted man should be instructed. In the category, are the execution of earth work, and field fortification. Each enlisted man has a tool for such work, in the same way that each infantryman has his rifle, and each cavalryman his horse. That he may do this work properly, he must be drilled in the defensive organization of positions, the improvement of the natural features of the ground, in the construction of bridges over small streams and ditches, and in the execution of all the small tasks that fall to the Engineers on the field of battle. Above all, he must be well drilled in earth work.

What after all, distinguishes an Engineer company from any infantry company, as regards proficiency in the construction of field-works—this term being taken in its widest sense? Two very different things. First; special technical instruction, comprising branches in which the infantry are untrained. Second; training in earth-work, which enables them to do more work in a given time, and above all to keep on working for such long periods as could not be attained by a man who knows how to use his tool but is not exercised in their use.

The necessity for training all Engineer soldiers as skillful and vigorous excavators, is very apparent when one studies closely the duties of Engineer troops on the battlefield, as we have endeavored to do in the case of field fortifications.

The recruits should, therefore, be drilled in earth-work at as early a date as is possible. Too much attention should not be paid to tracing and profiling, but as much digging as is possible should be done. One or two drills should be devoted to drill in rapidly commencing work.

To resume, there might be during the winter season two or three bridge drills under the conditions above indicated. The rest of the time would be given to earth-work and to field-works. As for all other tasks which would fall upon the Engineers in the field, it would seem that the company could always acquit itself satisfactorily, without requiring the recruits to serve except as combatants or workmen, if account is taken in regulating the details of instruction during the summer season of the vacancies annually produced by the expiration of enlistments.

APPENDIX.

We have alluded several times in the course of the article to the limited time available for the instruction of Engineer troops. Whatever the zeal and devotion of the officers, and however much the work required of the men, it is feared that this difficulty cannot be completely obviated.

Is it possible to apply a truly efficacious remedy to the situation, by attacking directly the causes of its existence?

The study of such a question so surpasses our ability that we would hesitate to attack it, if we did not consider it an imperative duty for every officer to contribute to the best of his power, however little those powers may be, to the progress which should be the constant law of our military organization.

Two principal causes tend to reduce the time available for instruction:

1st. The great number of special duty men which the companies furnish.

2d. The multiplicity of the duties of the arm.

The first of these causes has two equally regrettable results:

(*a*) By considerably reducing the number of men available for work and drill, it renders impossible the execution by company of certain drills that require a definite number of men; such as for example, ponton bridge construction. Recourse must be had to drill companies, a proceeding which furnishes a poor means for individual instruction, although it perfects, in some cases, the instruction of the organization.

(*b*) It reduces the length of time available for instruction. Almost all the men are on special duty at the end of the first year, some even as soon as their purely military instruction is completed.

It may truthfully be said, therefore, that there is only a single year, or rather ten months, available for the instruction of the men, and that this applies to men serving for three years as much as to those serving but one. All Engineer officers who have been on duty with Engineer regiments will appreciate the difficulties which are experienced in giving sufficient time to every part of the instruction in so short a period.

It does not seem that the situation can be sensibly modified, except by a radical change in our military organization. For several years, indeed, the inspectors-general, corps commanders, etc., have made an effort to reduce the number of clerks. The results obtained are certainly appreciable, but it must be admitted that nothing much remains to be done in this direction and that the small number of men which might perhaps be returned to the ranks, would scarcely work any change in the present state of affairs.

Let us then turn to the various duties of the arm.

These duties, numerous in the past, have recently been still futher increased when the regiments of pontoniers were abolished, and the ponton work was given to the Engineers. The ponton drill appreciably reduces the time which can be given to other drills.

It may then be asked whether all the Engineer troops, except the railroad and balloon regiments, should be drilled in ponton building, or whether it would not be preferable to specialize some of the companies in this duty, as for example the corps companies, leaving the divisional and garrison companies to receive the same instruction as in the past.

Up to the present time the former system has been followed, except as far as concerns the assignment of companies on mobilization.

There has been no increase in the enlisted strength of the Engineer troops to correspond with the increase in their duties. As the number of companies remains about the same, it would appear most difficult to assign a sufficient number of them to the new work without encroaching on the other duties of the arm.

There are other difficuties to be confronted. The old Engineer garrisons—Arras, Grenoble, Montpellier, Versailles—were chosen at a time when there was no thought of ponton duty for this arm. The result is that the troops must be moved and sent to large streams, where the breadth and rapidity of current will permit them to perfect the instruction that can only be outlined at their garrisons.

Such a proceeding requires considerable time, to the detriment of other important branches, which cannot be neglected, as they constitute an essential part of the instruction of some companies. A case in point is the instruction of the fortress companies in saps and mines. The school of mines requires, especially, considerable time for its proper treatment, so that it is very difficult to make an accomplished miner and a well drilled pontonier out of the same Engineer soldier in three years.

At first sight specialization would seem to be a remedy for the situation. The specialization might be applied to the companies as a whole, or to the soldiers in the company. The result would be the same—the number of subjects to be taught each soldier would be reduced, and more time could be devoted to instruction in the subjects taken up.

We propose, therefore, in the remainder of our remarks to consider whether this measure appears compatible with the proper preparation of Engineer troops for war, and in the case of the affirmative, whether it should be applied to individual men or to organizations, and under what conditions.

SAPS AND MINES.

Amongst the duties of Engineer troops, saps and mines were formerly the most important, as is shown by the name "sapper and miner." At present the employment of these works has been considerably modified, and has sensibly diminished, at least in the regular and almost rigid forms formerly affected. Again, the greater part of the Engineer troops go now, on mobilization, to the field armies, so that the school of saps and mines has little by little lost the predominant place which it formerly held.

Are we to believe, as we sometimes hear, that the powerful effect of modern siege artillery will do away with the inch by inch attack in the future? It would seem likely that such will be the case when an antiquated, incomplete, and badly defended fortress is attacked, as will undoubtedly frequently happen. A fortress properly prepared and defended with a sufficient garrison will, on the contrary, be a very different proposition. By such fortresses we particularly understand those which are provided with strong works for defending the flanks and intervals, so constructed that they cannot be destroyed by distant artillery, and serviceable after the most violent bombardment.

Is the building of such a fortification possible in the era of modern artillery? Without entering into too lengthy a technical discussion, we will say merely that the affirmative appears certain, and that it is prudent to assume it in any case. The assailant who attacks such a fortress will have to choose between a blockade and a regular siege.

What will be the nature of the works of approach in the sieges of the future? It would appear that they fall into two entirely different classes.

Until a certain distance from the fortress has been reached—a distance which will vary according to circumstances— the work will be that of putting the positions successively occupied by the assailant in a state of defense. To this end the assilant will improve natural cover, and will construct deep trenches provided with overhead cover at frequent intervals. Concealed communications, and the various approaches, will be so designed as to mutually resist the sorties of the defender.

The construction of these works is not essentially different from the construction of powerful field fortifications on a battlefield. It will be mainly carried on by the infantry. The Engineer companies employed with them can apply to such works little of their instruction in sapping and still less of their instruction in mining.

When the assailant has arrived sufficiently close for an assault, he may find that his artillery has destroyed the flank defenses of the works and their intervals, and has breached a wide passage through the auxillary defenses, the wire fences, and all the artifices for checking the assailants under the fire of the defenders. If this fire then appears sufficiently weakened and demoralized, the assault may be delivered at once.

But the action of the artillery on the essential portions of the works of the fortress, and on the auxillary defenses, may not have been effective. In such case the assailant should push his approaches up to the main line of the defense, in order to finish with the mine the destruction commenced by the cannon.

The distance over which the assault may be delivered is very variable. It depends on many factors, the most important of which is the temper of the defenders. If the latter, in spite of the losses and privations of a protracted siege, have remained active and energetic, an assault delivered over a distance may lead to a disaster. If the defender can man his ruined parapets with a line of riflemen and can succeed in mounting on them a few rapid-fire guns, at the moment when the artillery of the attack has ceased firing to avoid injuring its own troops, the assailant may meet a bloody repulse. The history of former wars offers many instances of this kind, and such an occurrence is even more likely to happen in the future, on account of the increased efficiency of modern arms. It will be necessary to push the cover for the troops that are to make the assault as close as possible to their objective. The construction of the necessary approaches under the close fire of the defense, the destruction of concrete counterscarps and counterscarp galleries, and the underground warfare against the countermines of the enemy, if such should be undertaken, are surely operations requiring the utmost skill, and should be prepared for by a training that is not necessary in the construction of approaches at a distance from the defense.

If the attacker finds it necessary to push his works as close to the defender as this, the defender will usually endeavor to retard his opponent's progress by means of under-ground warfare, carried on with all the means of modern science.

It would seem, therefore, that for a siege pushed to its extremity, as may sometimes occur, the employment of Engineer companies specially trained in such warfare will be necessary. But while it must be acknowledged that regular siege warfare must occasionable be carried on, yet such conflicts, if not exceptional, would at least be so unfrequent, that no very large number of Engineer companies need receive the special instruction pertaining to it. The present siege companies, with the corresponding reserve and territorial companies, should furnish sufficient men to defend our own forts, or to attack those of the enemy if the war should fortunately be waged in foreign territory.

It is a question, therefore, as to whether we should not divide the Engineer troops into siege and field companies, and specialize both their instruction and their duties.

Siege corps and garrisons of fortified places would include Engineer troops of both classes. The field Engineer troops would be assigned to the construction and care of communications in general, and, when necessary, to ponton bridges in particular. They would assist the siege companies in putting the fortress in a state of defense, and in the construction of advanced posts at a distance from the works.

With the exception of that portion of the instruction that relates to field operations, such as the employment of explosives in demolitions, and in breaching walls and auxillary defenses, the school of mines would then be omitted from the instruction of the field companies. The little that can now be taught them appears in any event insufficient to fit them for any service except that of auxillaries in the close attack or defense of a fortress. Again, such instruction would not seem necessary in the preparation of the outer line of resistance on the defensive, or in the construction of the distant approaches on the offensive.

On the other hand saps and mines would become the essential part of the instruction of the siege companies. This instruction would include field fortifications in addition, but bridges would be taught only to field campanies.

BRIDGES.

As we have mentioned before, most of the posts of Engineer regiments are not suitable for completeing their instruction in ponton-bridge building. It is, therefore, necessary to send each year a number of companies to a water-course of sufficient breadth and velocity of current, in order to complete their instruction.

The proper method for accomplishing this is doubtful, and of recent years there has been no uniformity as regards the river selected, or as to the troops designated for the duty.

Since we have lost the Rhine, the Rhone is the only one of our rivers which realizes the most favorable conditions for the instruction of pontoniers. With a very hard bottom offering little hold for anchors, great breadth, and a rapid current, it unites all the difficulties which must be overcome.

The ideal arrangement would be to send all the companies that might be assigned to ponton work to this river each year.

There would, however, be two objections to this arrangement, under the present conditions at least.

The first is the necessary expense. As the regiments at Arras, Versailles, and Angers are quartered in towns at a long distance from the Rhone, the expense of transporting the troops by rail would be heavy, and should be reduced to the lowest possible amount. The facilities for quartering troops on the banks of the Rhone are at present very limited, and new barracks must be constructed if all the companies are to be sent to this river for a sufficiently long period. This would involve a further expense that should be avoided if practicable.

The second objection is the time required for such instruction. This would decrease the number of drills that could be devoted to the other branches of instruction, and these latter could not be properly taught.

One solution which was employed, was to send to the Rhone a certain number of picked men only, forming a provisional company from each regiment. The remainder of the men finished their instruction at rivers relatively near the garrison, such as at Elbeuf on the Seine, for instance, for the Arras and Versailles regiments.

Although this procedure removed the first of the objections, it did not affect the second. For this reason, undoubtedly, a different system has been instituted. Under the new arrangement the Rhone only is utilized for completing the instruction of the men. Each regiment sends as many drill companies as it has battalions. The divisional and corps companies each furnish forty men to be specialized as pontoniers, the remainder being instructed as miners.*

If the relative advantages and disadvantages of these two methods be compared, it will be seen at once that the first provides instruction by company, but this is not regarded as a very important point. By taking care that enough non-commissioned officers are sent to the Rhone, the company commanders would secure a sufficient number of chiefs of ponton who are skilled in maneuvering the boats in rapid water. But while the chiefs of ponton would be properly drilled for the construction of a bridge on such rivers as the Rhine or Rhone, it is to be feared that the crews would not have sufficient training to work quickly in such a rapid current.

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* This specialization is, however, only partial, since it relates only to the higher instruction. The enlisted men in the field companies receive at first an elementary instruction in both bridging and mining. We would call attention to the difficulties of properly carrying out the more detailed instruction of the miners of the field companies, under such conditions. After the companies have sent forty men to the bridge instruction there are few left for drill, as ordinarily it is very rarely that the company turns out as many as forty men for drill.

The second solution, on the other hand, would seem to provide each company with a sufficient number of well trained men to form the anchor and boat detachments for work in any stream.

In this case, however, the instruction is not conducted by the captain, but by all the officers of the regiment in turn, for these officers take up this duty in succession. This is a very serious matter. Its gravity is apparent when we examine in detail the way in which the instruction is carried out.

The drill companies must supply the guard and fatigue details, and these absorb a considerable number of men. In addition there are the musicians, orderlies, telegraph operators, cooks, etc., who are never present at drill. These details reduce considerably the effective strength of the forty trained men that the bridge drills should give each company. Even the men available for duty are not uniformly instructed.

In addition to those detailed for duty with the drill companies, the other officers of the regiment spend about a week on the Rhone. During this time they are each called upon to take charge of two or three drills. As is proper, they are careful to see that the drills that they conduct are correctly executed. They direct the officers who are their assistants to select their non-commissioned officers accordingly. The inevitable result is that the chiefs of ponton who have shown skill and coolness at the beginning of the drill period are always assigned to these most difficult posts, which consequently impart the greater training, while the others are put at lashing side rails, constructing the abutments, and, above all, carrying balk and chess. The men in their turn are assigned to their duties according to their proficiency by the non-commissioned officers in charge of the detachments. Even if they so desired it would be hardly possible for the officers, who are being constantly changed, to establish such a rotation of duties that all the men would be put through each variety of work a few times.

The result is that the number of men in each company really instructed in building a ponton bridge in a rapid current is reduced from the total of forty which it should have, to twenty, fifteen, or even less. This is another instance of the unfortunate result of drilling men in special platoons, drill companies, or anywhere except in their own companies.

Neither of the two methods of instruction, successively adopted, appears to be quite satisfactory therefore, and it does not seem easy, with the present organization of Engineer troops, to find a solution that gives at once efficiency and economy. It is particularly hard to avoid the difficulty that arises from the fact that as the bridge drill is rightly considered of the highest importance, all the field companies have come to devote so long a time to it that the other branches of instruction are appreciably neglected.

May it not then be asked whether under such conditions, it would not be preferable to specialize a number of companies as ponton companies, even admitting that such a measure is incompatable with the duties that the Engineer companies, as now assigned to the army corps, are called upon to perform?

If one of the Engineer companies of an army corps is to be specialized as a ponton company, it would naturally be the corps company. Should not this company be able to execute alone all the duties connected with the bridge train?

Let us consider the most unfavorable case; that of an army corps marching on two parallel roads with a division of the bridge train in each column. The two bridges which might be required in such a case could be easily built by a platoon of the corps company, since the work would require at the most, for each of the bridges, but 97 men, of whom 28 (the balk and chess detachments) could be any auxiliaries whatever. If an advance guard bridge train marches at the head of each column, its service could easily be attended to by a section of the corps company.

In a word, the available strength of that company, supposing that it is reduced almost one-half, will be sufficient in every case to handle, under normal conditions, all the material of the bridge train pertaining to the army corps. The essential point is that it should be within reach. Now it is certain, by reason of the relative position which the units occupy in the columns, that the corps company will be able to reach the site of the bridge at least as quickly as the bridge train.

As far as the bridge train is concerned, therefore, it does not appear that there would be any difficulty to assigning the duty to the corps companies exclusively. Such companies alone would consequently receive the corresponding instruction.*

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*In order to treat the question thoroughly, it would be necessary to discuss the influence of such a measure on the formation of the reserve, but a study of this nature would be out of place here. We may say merely that the sole consequence that should result from it would be the necessity of maintaining, in the composition of the reserve companies, some ratio between the respective number of the men who have served in the corps companies, and those coming from the divisionary companies. It does not seem that any difficulty would result from this.

The present condition of affairs was predicted by many officers, when the pontonier regiments were abolished, and there were some who advocated the reorganization of these regiments by collecting at Angers and at Avignon the third companies of the Engineer battalions.

It would seem that this last arrangement would be unfortunate from several points of view. As the corps companies would form separate regiments, and as they would be the only troops that were given ponton drill, they would gradually allow this portion of the work to monopolize their time, and would regard everything else as subservient to it. Under such conditions the divisional companies would have to perform all the duties in the army corps that fell to the Engineers before the pontoniers were abolished. They would be unable to cope with such a task. There is another point of great importance, which is that the Engineer troops attached to an army corps, should all belong to the same organization in time of peace.

Thus specialized, the corps companies would be the only ones that would have to be sent to the Rhone to complete their training, and this training could more advantageously be conducted, since separate detachments would no longer be grouped into drill companies, but the companies would remain intact under the command of their captain, who alone is responsible for the instruction of his company.

These companies would not be on this account mere ponton companies. The special instruction in bridge work, however completely carried out, would not absorb all the time outside of the purely military drills. Their program of instruction would include the use of explosives and the construction of field fortifications.

When the corps companies were not acting as pontoniers—and this would be the ordinary condition—they would be employed on the duties of constructing or demolishing lines of communication, and in fortifying the field of battle.*

The divisional companies would be trained only in the former Engineer bridge instruction, that is to say, they would be drilled, concurrently with the corps companies, in the construction of bridges, using material found on the spot.

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*The specilization of the corps companies as companies of pontoniers, above outlined, could not be regarded as a return pure and simple to the old organization, for it would not present the two essential objections which were to be found in this latter, viz:

1st. All the engineer troops having charge of communications in the army corps were not united under the same commander.

2d. The pontonier company could be employed only in the construction of bridges.

FIELD FORTIFICATION.

The conclusion from the considerations in regard to saps, mines, and bridges above set forth, is that if the engineer companies are specialized as indicated, field fortifications would be taught to all the companies. It would merely be necessary to consider their assignment on mobilization, and regulate accordingly the details of the instruction given to each. Thus, for example, the division companies, having no longer to deal with saps, mines or the bridge equipage, could consequently devote considerable time to the works of the battlefield. Company commanders would employ this time in perfecting their men in excavation, in rapidly laying out field works, and particularly in fortifications on varied ground. These last drills are the only means of studying in detail the work of such varied nature as would fall to them on the battlefield, when acting in conjunction with the infantry.

We have set forth in this appendix the reasons for the specialization of Engineer troops.

We may have overlooked considerations that are opposed to the adoption of such a measure. So, leaving the decision to more compentent and experienced authorities, let us be careful not to rashly draw final conclusions. Our object is attained if by submitting this work to our superiors and comrades, we have added a useful, though modest, contribution to the study of the most important question pertaining to the service to which we have the honor to belong—the preparation of Engineer troops for war.

POTEZ,
Capitaine breveté du génie.

DEC 21 1922

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No. 10.
OCCASIONAL PAPERS,
U.S. ENGINEER SCHOOL OF APPLICATION,
UNITED STATES ARMY.

INSTRUCTIONS

FOR THE USE OF

STEEL PONTONS AND HALF-PONTONS

FOR CAVALRY

IN THE GERMAN ARMY.

ENGINEER SCHOOL OF APPLICATION,
WASHINGTON BARRACKS, WASHINGTON, D. C.,
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The accompanying report was furnished to the Second (Military Information) Division, General Staff, by Captain W. S. Biddle, 14th Infantry, Military Attaché, Berlin, Germany. The translation was made by Major H. F. Hodges, Corps of Engineers.

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INSTRUCTIONS FOR USE OF STEEL PONTONS AND HALF-PONTONS FOR CAVALRY.

This material is intended only for cavalry service and forms part of the equipment of each cavalry regiment.

Each cavalry regiment has at its disposal four steel half-pontons with their regular appurtenances, all of which, for each set of two half-pontons, are loaded upon one ponton wagon of special construction.

The equipment is as follows:

For one wagon.		For one regiment.
2	Steel half-pontons, 118 kilograms	4
3	Saddle pieces, 3.45 metres	6
4	Flooring panels, 4m x 1m	8
2	Sleepers	4
3	Stanchions (for railing)	6
1	Anchor	2
6	Oars	12
6	Oar locks	12
4	Boathooks	8
2	Anchor ropes	4
8	Railing ropes	16
4	Lashings	8
6	Stakes	12

DESCRIPTION OF MATERIAL.

1. *The Steel Half-Pontons.* (Plates 1 and 2.) This is made from steel with a high percentage of nickel. The pointed end of the half-ponton is called the bow; the angle of the bow is called the stem. The end of the half-ponton opposite the bow is called the stern.

The framework of the ponton consists of steel ribs upon which the skin plating is riveted.

A strip of wood is worked around the upper and outer edge of the half-ponton to form the gunwale.

There are holes in the gunwales to receive the oar locks, and others to receive the tenons of the saddles and the stanchions of the railings.

On the inside of the bottom of the boat are placed two cavils, one near the bow and one near the stern, to which the anchor ropes may be fastened, after the assembling of the two half-pontons.

The skin of the boat, which is of sheet steel, is protected on the outside by three wooden battens worked lengthwise along the bottom, and on the inside by five wooden battens similarly placed along the frame. Besides these, two wales of wood are worked along the outside of the boat lengthwise as fenders, and serve also as supports for the other half of the boat when the two are loaded, one above the other, on the ponton wagon (see Plate 5). In addition, also for the purpose last mentioned, there are five small braces worked between the gunwale and the waling strip on each side of the half-ponton, each* brace being provided with a hook, which helps in securing the half-ponton to the wagon, and in securing the flooring to the boat when the bridge is constructed.

The two half boats are assembled by means of a hook and eye (Plate 1) on the outside of the transom forming the stern of the half-ponton, and are secured also by lashings passed around the cavils in the bottom of the half boats. The parts can be assembled on land or in the water.

2. *The Saddle.* (Plate 3). This is made of pine. The ends engage by hooking into seats prepared for them, one at the bow of the half-ponton, and the other in the inside of the gunwale of the stern transom (see Plate 1).

The seats for the joists of the flooring panels are protected by sheet metal. The other holes in the upper surface of the sill are for the stanchions of the railing, different ones being used for the narrow footbridge and for the wide footbridge, both when built with whole pontons, and for the service bridge, as well as for the wide footbridge when built with half-pontons. The sill is also used as an abutment sill for the larger bridges, being sunk a little in the ground and held in place by the stakes.

3. *The Flooring Panels.* (Plate 3). These are made of pine, each panel having three joists to which the wooden planks are secured. All these joists engage on the saddle, the outside ones by means of brackets and the middle one by a hook. In building a ferry-raft of whole or half-pontons, the joists are supported by the gunwales of the boats.

The iron strap in the middle of each of the panels and the two holes at the end of the same are to engage the hooks of the sleepers (see Plate 4), used when the wider bridges are built.

**Sic* in the text. The plates indicate the hooks on alternate braces only.

4. *The Sleepers.* (Plate 4). The sleepers are made of pine reinforced with iron, and serve to support and clamp together the panels of flooring ing in the wide footbridge or the service bridge. Each sleeper has four hooks, with hand-nuts or thumb-screws at the lower end of the shank, allowing the hooks to be drawn tight by hand. The outside hooks have one branch, the two middle hooks two branches. The nuts or thumb-screws on the bottom are locked fast after drawing up, by rings arranged to pass over one of the arms and prevent the nut from working loose.

5. *The Stanchions.* (Plate 4). These are made of ash, each with an iron shoe and tenon at the lower end, which fits into one of the holes in the saddle piece, or gunwale, according to whether a bridge or raft has been built. The stanchions project 1^{m} above the flooring. The upper extremity is provided with an iron cap and ring through which the hand line is placed and secured.

6. *The Anchor.* This has two flukes and the usual stock.

7. *The Oars.* These are of pine and 3^{m} long. The blade is shod with iron and has rounded corners.

8. *The Oar Locks.* These are of iron and of the usual type.

9. *The Boat Hooks (or Poles).* These are of pine, round, 4.2^{m} long, 5^{cm} thick in the middle. The lower end is blunt and shod with iron.

10. *The Stakes.* The ropes or lines belonging to the equipment are as follows:

	Length.	Diameter.
Anchor rope	35.0^{m}	1.5^{cm}
Railing line	6.5^{m}	1^{cm}
Lashings	2.5^{m}	0.8^{cm}

11. *The Stakes.* These are of ash, 0.5^{m} long and 6^{cm} thick. They have iron points and are capped with iron.

The manner of loading the ponton wagon is shown on Plate 5, herewith. The equipment loaded on one wagon is one-half of that carried with a regiment of cavalry.

ADDITIONAL EQUIPMENT FOR ONE REGIMENT.

Two Ponton wagons, Prussian model; 1 small shears, 1 shears for cutting sheet metal, riveting tools, 1 piece sheet steel, ½ sq. m.; rivets, spare parts, iron; 1 tool chest, 1 box for rivets.

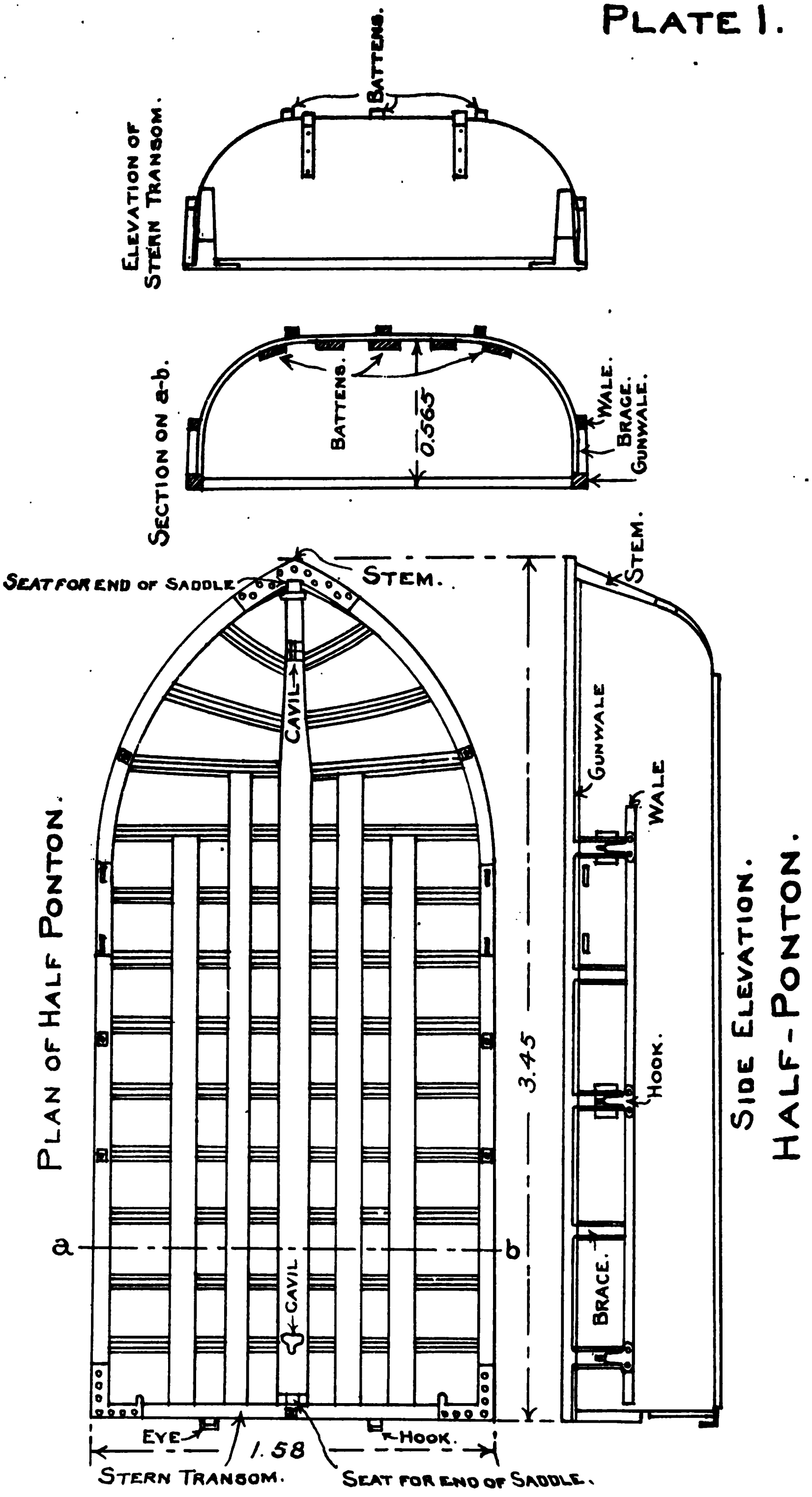
DIMENSIONS AND WEIGHTS.

	Weight kg.
Steel half-ponton	118.
Saddle pieces, about 3.45^{m} long	20.

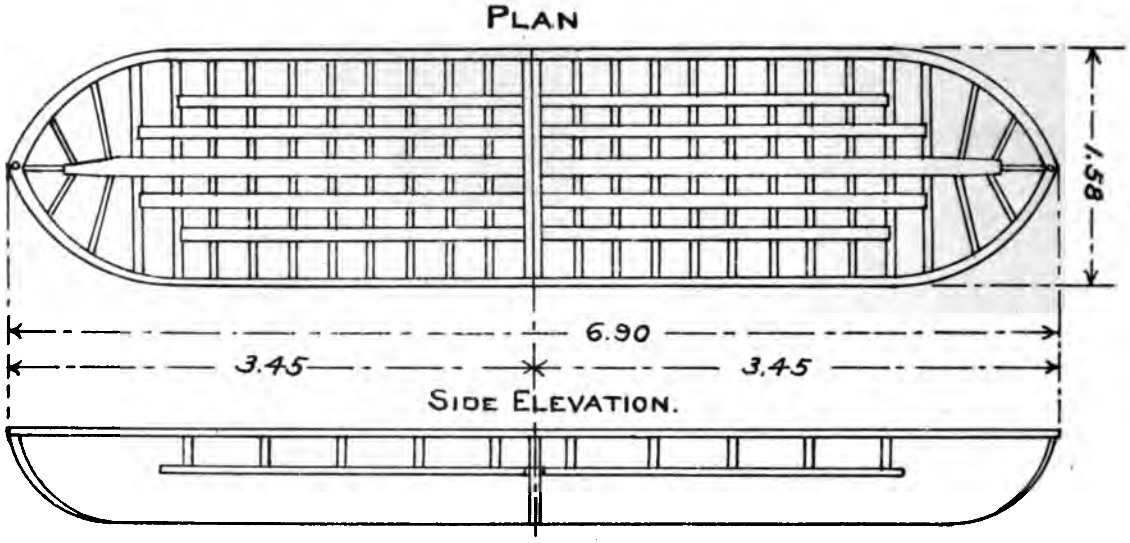
	Weight kg.
Flooring panel, 4^{m} long, 1^{m} wide	90 to 95.
Sleeper	45 to 50.
Stanchion	2 to 2½.
Anchor	25 to 30.
Oar	4 to 5.
Oar lock	3¾ to ½.
Boat hook	3½ to 4.
Anchor rope	9 to 10.
Hand line	3½ to 4.
Lashings	1 to 1½.
Stake	½.
Ponton wagon	1,580 to 1,600.

The dimensions marked on the plates are in meters.

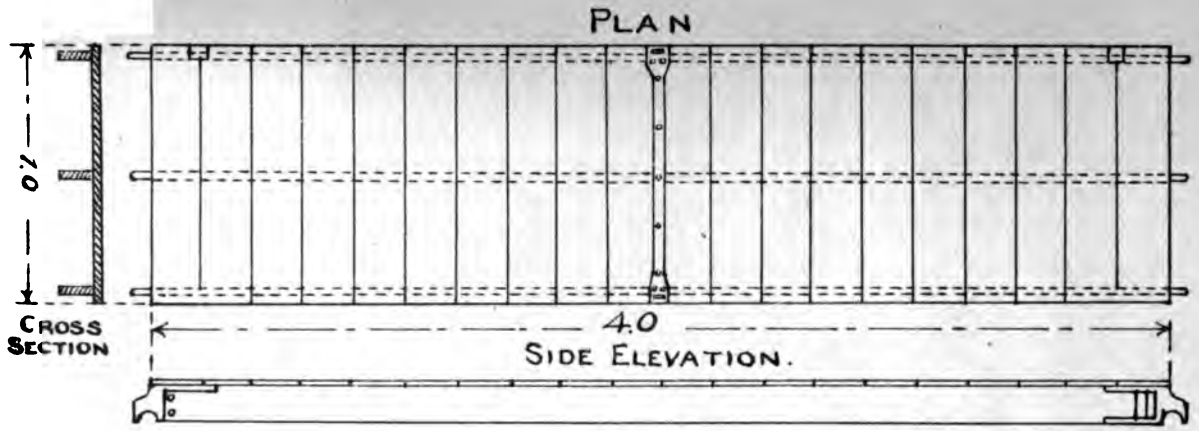
PLATE I.



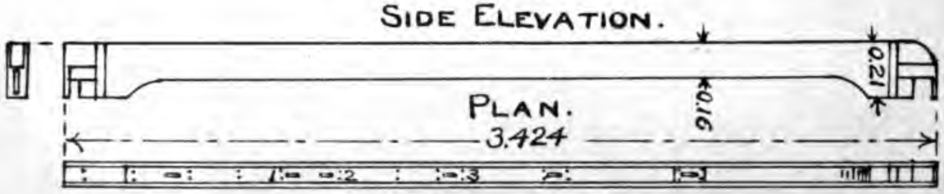
HALF-PONTON.



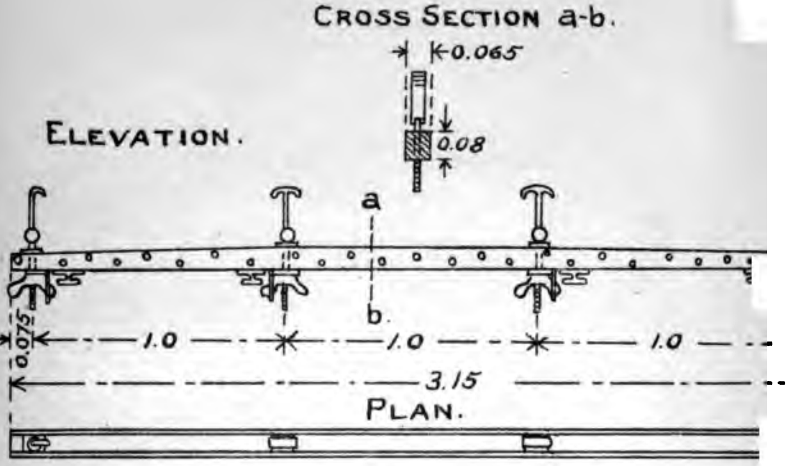
PONTON, ASSEMBLED FROM TWO HALF PONTONS.



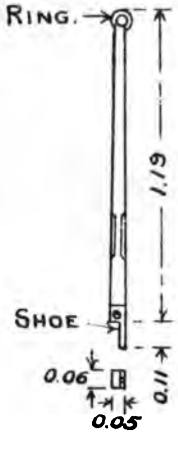
PANEL OF FLOORING.



SADDLE.

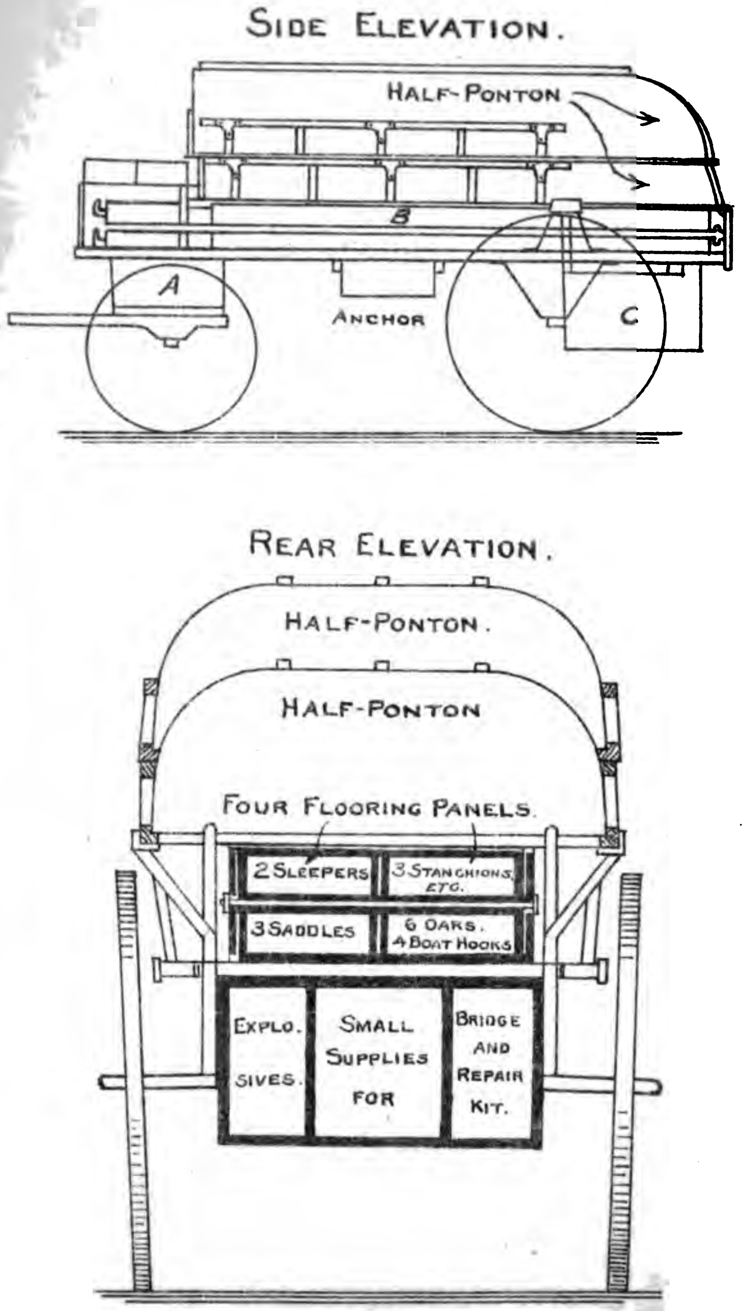


SLEEPER.



STANCHION.

A. Limber chest with supplies for wa
B. Bridge material
C. Chest containing explosives, small supplies an
repair kit.



PONTON

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Remarks on SEARCH-LIGHT PROJECTORS FOR COAST DEFENSE SERVICE

By
FIRST LIEUTENANT A. E. WALDRON,
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and
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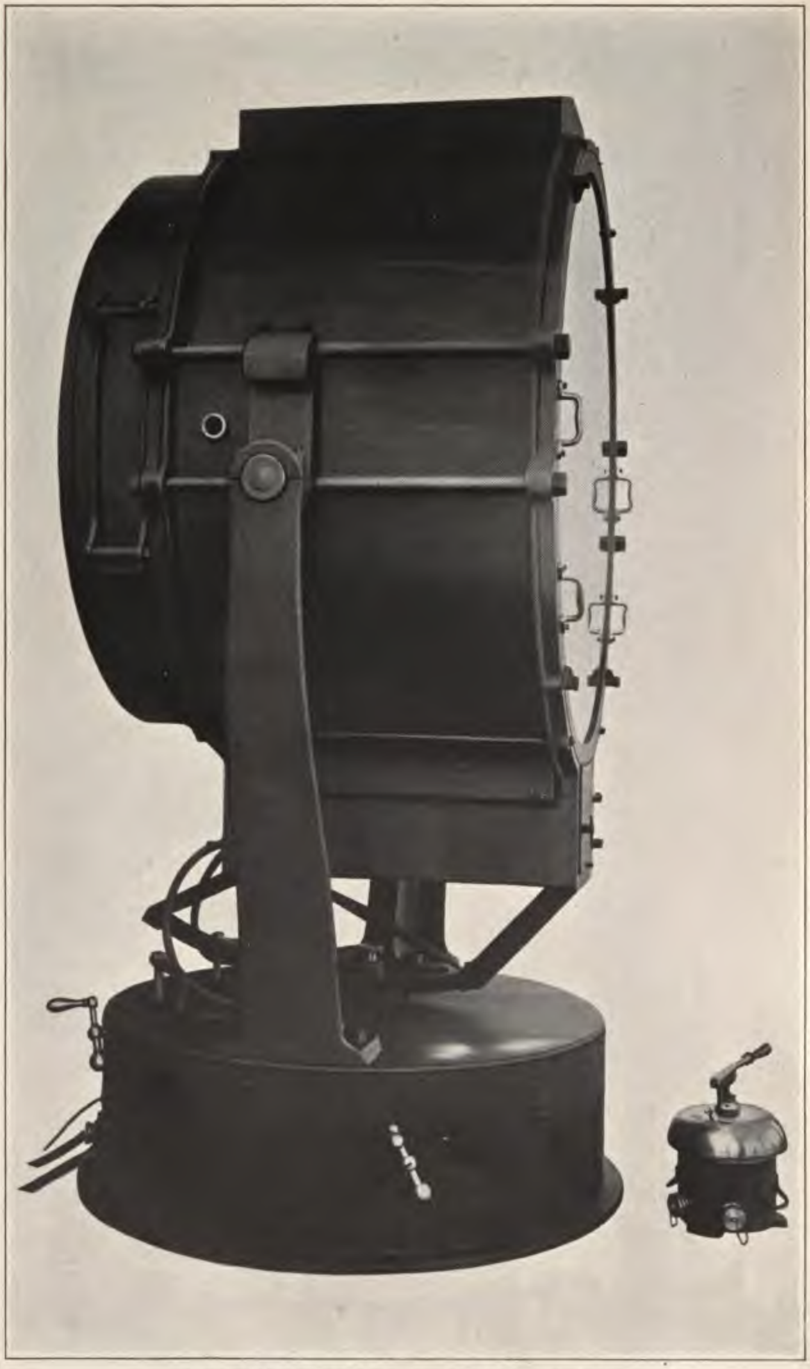


A 60-INCH PROJECTOR AND CONTROLLER.

SEARCH-LIGHT PROJECTORS FOR COAST DEFENSE SERVICE.

The use of search-lights in modern warfare is an absolute necessity, no seacoast fortification being complete without them. Their value as an aid to seacoast batteries in repelling night attacks depends upon the number, size, location, and control of the search-lights and the reliability of the power supply. Inefficiency in any of these points is sure to be felt; and an energetic enemy is sure to notice and take advantage of them. It is of interest to note each subject in turn and its influence upon the general efficiency of the search-light system, as by this means some features that are detrimental to the system may be eliminated and others altered to improve it.

Local conditions, as in all other engineering projects, are the controlling features. This makes it impossible to adopt hard and fast rules, but the average conditions admit of a few general remarks which are, without very great changes, applicable to all.

Search-lights have been classified, according to the duties to which they are assigned, as searching, illuminating and blinding lights. The combined Army and Navy maneuvers have shown conclusively that blinding lights, while they cause considerable trouble with the merchant marine, are not real obstacle to warships. This leaves for consideration searching and illuminating lights. All lights of each distinct and seperate fire command should be under the control of one man, who should have complete control of them. The lights should be divided into searching and illuminating lights, and each should confine itself to the duties assigned to it; or, in other words, no search-light in either class should attempt the duties of the other, unless accident compels a reassignment of the lights, which should be in accordance with a prearranged plan.

Aside from the regular duties an important feature of any system of defense is the protection of the home fleet. The opening events in the present war between Russia and Japan have shown the desirability of an efficient search-light system. The present automobile torpedoes with an initial speed of 30 knots have a range of from 800 to 1,000 yards, but as it is quite probable that in the near future a torpedo having an initial speed of 40 knots and a range of from 1,200 to 1,500 yards will be designed. It is, therefore, important that the search-light system be able to pick up and illuminate torpedo-boats moving into an attack, in sufficient time to repulse them before they have attained the range given above.

NUMBER OF LIGHTS.

The number of distinct and seperate targets that can be subjected to an overwhelming fire at one time, determines the number of illuminating lights. In some cases this would be one for each fire command, in others one for each gun, but the more general solution will be one for each battery. Under the head of illuminating lights some would place such lights as the FIRE COMMANDER'S and DISTRICT COMMANDER'S. If such lights are used they should be in a class by themselves, but with an efficient system of searching; especially as when there are boats out patrolling the offing they cause more trouble than good, and their use is not warranted.

If mine-fields are located in exposed places it may be necessary to keep them illuminated; but on the other hand if a certain spot is kept illuminated, a mine-field will be suspected and avoided, or a submarine boat may countermine this lighted area. For these reasons, it is believed to be a better policy to depend upon the searching lights to expose any tampering with the mines. Should it be considered necessary to illuminate these places more lights will be required than outlined above

The number of searching lights is more difficult to determine and much thought must be given the subject to obtain the best results. The information available will be the extent and depth of the water area, location of the channels, the outline of the coast and the location of the batteries. To thoroughly search all avenues of approach and avoid the intersection of beams, with the fewest lights, is the problem to be solved. Experience has shown that one beam intersecting another masks objects beyond the intersection, even if they are actually in one or the other beam; or to express it otherwise, it is quite difficult to see through a beam of light from a projector. It will be found best to assign to each searching light a fixed sector, the limits of which are determined preferably by natural land marks; and no search-light should be allowed to encroach on the sector assigned to another. For the same reason it is wise to keep all illuminating lights occulted until wanted for the use assigned to them. For if beams are permitted to intersect, a number of torpedo-boats or the fleet itself, might steam in close, masked by the interfering beams, and by taking advantage of a temporarily unilluminated area of water make a dash for the harbor. The extent of the water area and the angular distance covered by each sector will determine the number of searching lights.

As ships in war time will be painted a color which will render them as inconspicuous as possible, they will be able to steam in much closer without being discovered, and a sharp eye and strong illumination will be required in order that they may be picked up in sufficient time. A fleet making an attempt to close in on the batteries or run into the harbor will take advantage of the time required for each search-light to search from one limit of its sector to the other. This time must be kept as small as possible, while, on the other hand it has been found by actual trial that an angular velocity in azimuth of 360 degrees arc, in 15 minutes of time, has given the best results of for searching. Higher speeds do not afford sufficient time for a critical examination of the illuminated area. This movement corresponds to one degree of arc in 2.5 seconds, and to determine the time of one complete cycle, allowance must be made for the return to the starting point, which will make 5 seconds per degree of arc. Furthermore, as the beam will undoubtedly be stopped to examine objects which are not at first fully recognised, a further increase must be made for this, and an equal time is assumed. This added to the 5 seconds, makes the time 10 seconds per degree of sector, which is a conservative estimate; in a majority of cases the time will be considerably more than ten seconds.

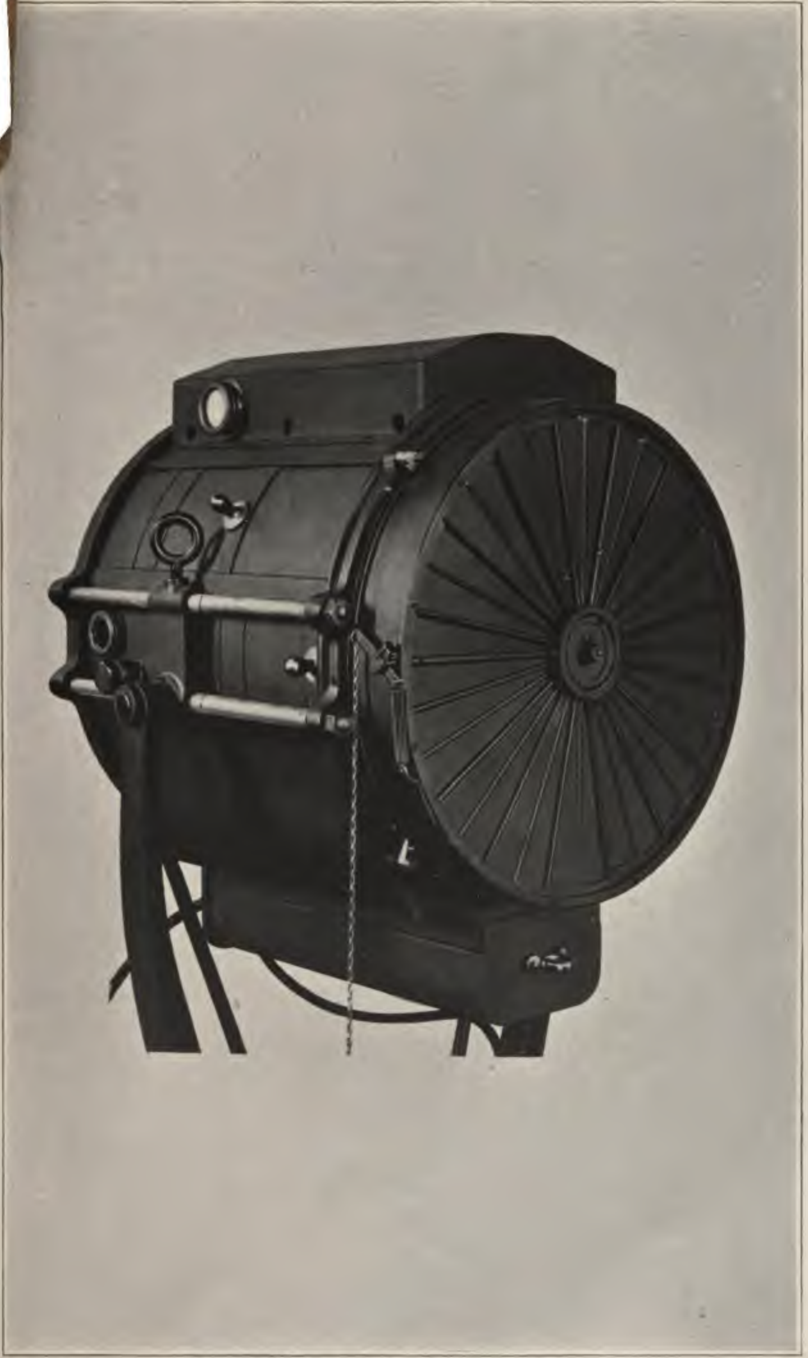
A torpedo-boat steaming at 30 knots an hour moves in one second approximately 50 feet, and while the beam is swinging through one degree of sector will move about 500 feet. It will be seen that if but few lights are used, the sector assigned to each increases; and assuming a sector of 90 degrees, during the time of swinging from one limit to the other and return, such a torpedo boat would be able to steam a distance of 15,000 yards. So that by reason of thick weather and partial invisibility due to color, it might be able to steam close enough, without being observed, to deliver torpedoes of maximum range with high chance of success. It would be a simple matter for the enemy to create a diversion, by keeping one or two torpedo-boats steaming about attracting the attention of the searching lights, thus increasing the opportunity for the attacking boats to steam in. To avoid such a possibility, it is desirable to divide the water area into a number of sectors as small as possible, and assign to each a searching light. A sector of 20 degrees will not be too small to assign to one light. This sounds extravagant, but it would mean only nine searching lights when conditions were very unfavorable; that is, with deep water in all directions and 180 degrees of arc to cover. The configuration of the coast, the location of the channels, and shallow water, will in most cases considerably reduce the number of searching lights required.

SIZE OF LIGHTS.

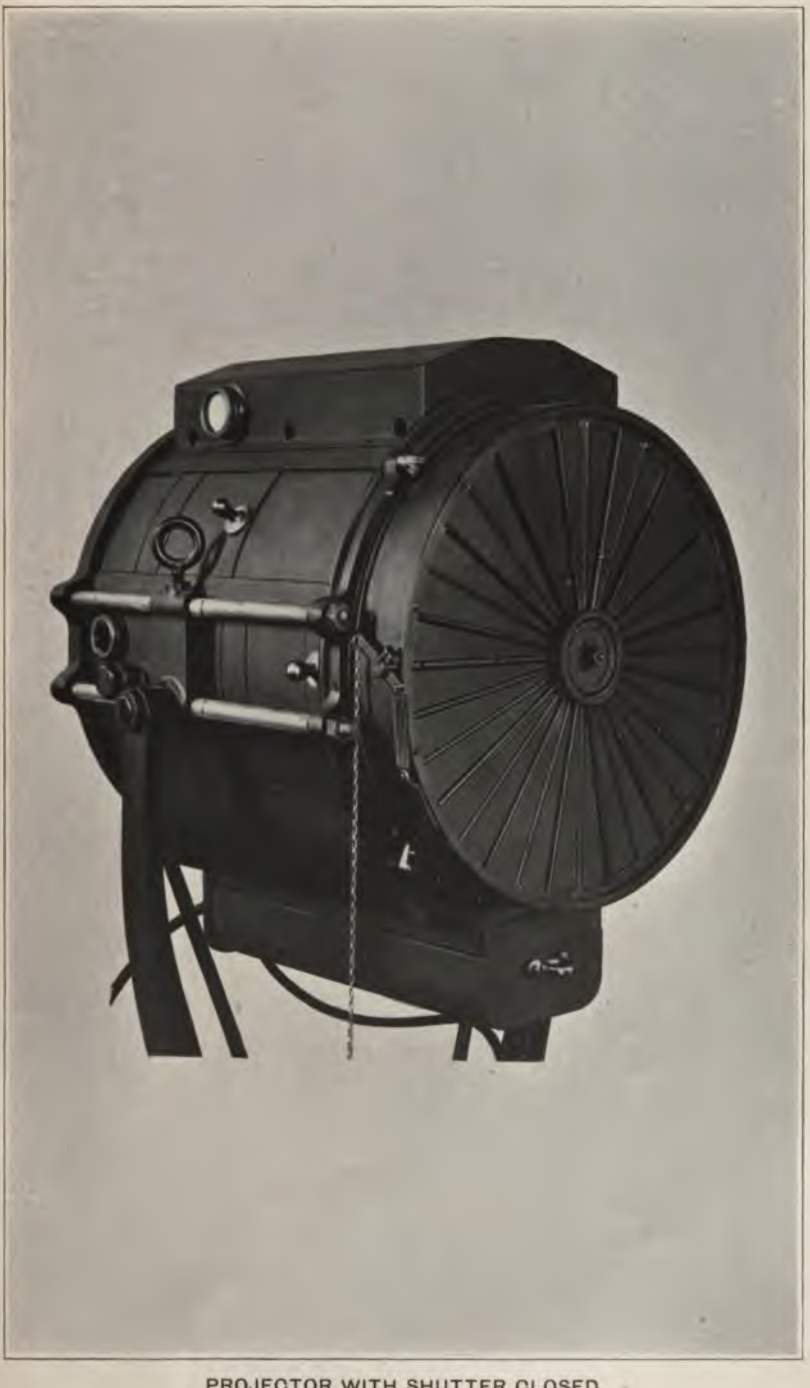
For efficient use of range finding instruments, it is necessary to illuminate the objective as strongly as possible at comparatively long ranges; this means large illuminating lights. But before a target can be turned over to an illuminating light, it must be picked up and identified by a searching light, at a distance as near the maximum range as possible; and, also, as it is more difficult to see an object when temporarily illuminated by a swinging beam, than after it has been in the beam for a short time, or after the eye has had time to adapt itself to the new conditions, searching lights must be as large as, if not larger than, illuminating lights. Therefore, projectors of a maximum illuminating power should be selected, and it is probable that the 60″ size will be most suitable, although, in rare locations, such as restricted channels, the 36″ size might be used.

LOCATION OF LIGHTS.

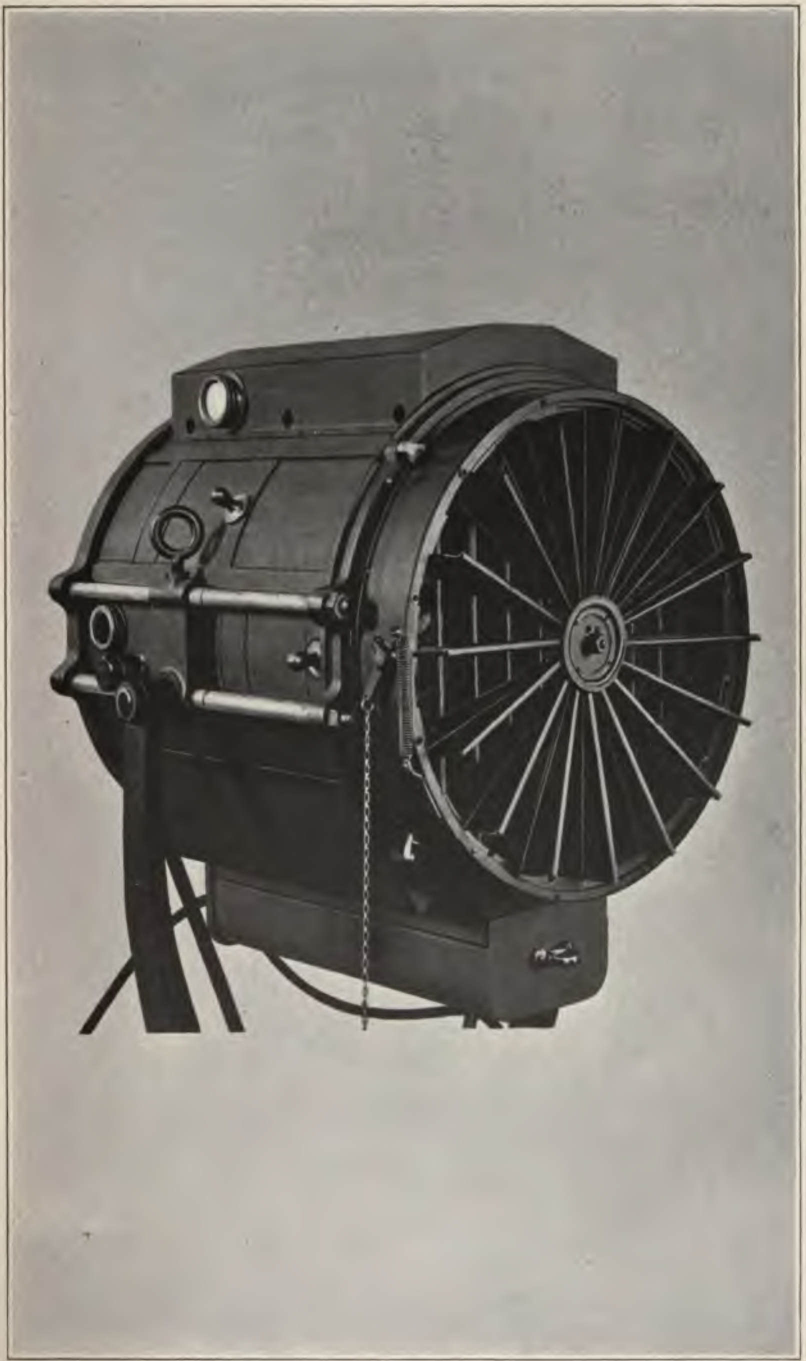
The location of the lights with reference to the observing station affects the visibility of objects at the working range: an observer near a search-light is unable to see the objects illuminated as clearly as one some distance to one side of the beam. Therefore, all searching and illuminating lights should be placed well to one side of the controlling or observing station. This location has been tried repeatedly and search-lights installed in this way have given better results than those located near the observer. The question of high and low sites, within reasonable limits, is not important and may be satisfactorily settled by selecting a location of such height that the beam will be approximately tangent to the water at the working range; as,



PROJECTOR WITH SHUTTER CLOSED.



PROJECTOR WITH SHUTTER CLOSED.



PROJECTOR WITH SHUTTER OPEN.

by this means, a greater area of water is illuminated. Other points for and against a certain location, such as concealment, distance from power supply, etc., can best be decided by local conditions.

CONTROL OF LIGHTS.

For efficient service, it is necessary that the control of the light be in the hands of an observer, and as the principle observer ought to be at least 1,000 feet from the light, this means electrical control at this or greater distances. The system should be such as to avoid the necessity of handling the motor current in the controller and controller cable, as this will avoid excessive drop of potential in the latter which would effect the speed and power of the training motors. As mentioned before, velocities in azimuth ranging from 360° of arc in 15 minutes of time, to a maximum speed of 360° of arc in one minute of time, should be provided; the higher speed for rapidly shifting the beam from one object to another at need. This requires at least two speeds, one but $\frac{1}{15}$ of the other. The controlling system should take care of this. It is impossible to get this range of speed by motor regulation, and reliable means other than this must be provided. It is also advisable to have all the movements—not only the different speeds in azimuth, but the training of the beam in a vertical plane, as well as in a horizontal plane—controlled from one lever or handle at the controlling station; simplicity in this respect limiting the chance of error in training, and saving much confusion.

A device that has never been provided for coast defense search-lights might be used to advantage, namely, a shutter which will occult the beam when necessary, the shutter mechanism being operated from the controlling station. Without this, to occult the light it is necessary to open the lamp circuit, and as the lamp burns badly when first started, during the formation of the crater, the addition of the shutter would be an advantage: the lamp being allowed to burn continuously, but the beam being shown only when required. The expense of burning carbons, when the projector is not in use is too small an amount to be considered. The power, however, is somewhat of an item, but even this need not be considered when reliability is compared with cost. A shutter without electrical attachments is shown herewith. It would be an easy matter to equip this shutter with an electrical device which could be operated from the controlling station; that is from a point 1,000 to 3,000 feet from the projector.

The system of control of projectors, lately installed, is illustrated in the diagram. This has successfully controlled lights from a point over 3,000 feet from the projector and can be extended to further points if necessary. In later shop tests 16,000 feet of cable has been used with success. This system takes care of all the points noted, except the shutter, which could be operated by a separate switch added to the controller.

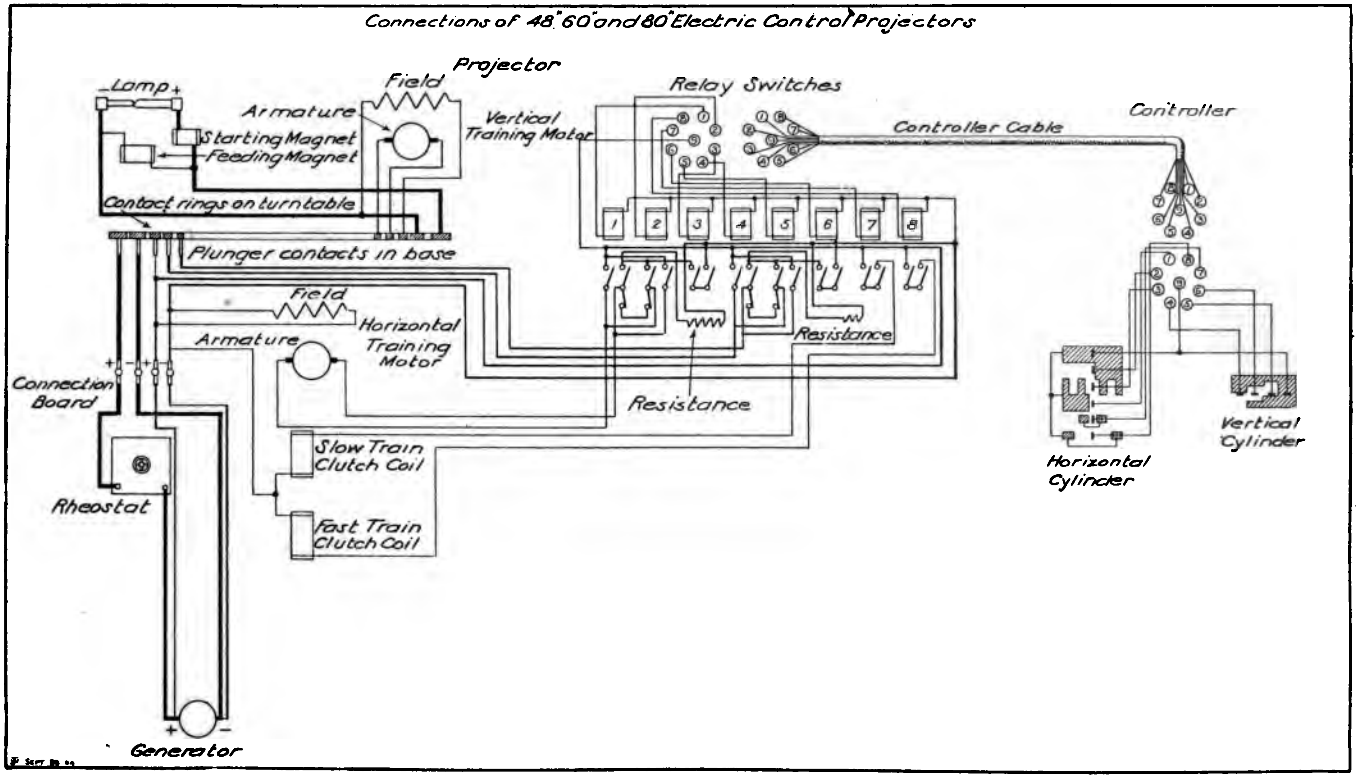
The heavy lines represent the lamp connections or those carrying the heavy current for the arc, the medium lines the connections of the training motors, and the light lines those of the magnetic clutch system and the control of the electro-magnetic switches or relay system. It will be noted that each motor has three electro-magnetic switches which determine the direction and speed of rotation. Two of these contol the direction of rotation; the third when operated in connection with either of the others, short circuits a resistance in series with the motor armature, increasing the speed of rotation. The gearing in the horizontal system, not shown in the diagram, has two ratios of reduction between the motor and the projector's turntable, giving two speeds, one of which is 15 times as fast as the other. Each gear train is controlled by the action of an electro-magnetic clutch, which in turn is operated by an electro-magnetic switch.

In cases where it is desirable to equip the old style 30″ or 36″ projectors with long distance control, a relay switch case can be obtained which can be placed near the light, the old cable being attached to the case containing the relay switches and the new controlling cable being carried as far as desired. This would not give the two speeds having the ratio of 15 to 1, but simply the old control, extended to 16,000 feet if necessary.

POWER SUPPLY.

The use of search-lights under conditions found in the service renders the distribution of power to obtain reliability, good regulation, and low cost of installation and maintenance, a matter for serious consideration.

During the past two Army and Navy maneuvers, the writers have become convinced that in the majority of cases, on account of the higher illumination, the 60-inch projector will be the most serviceable. And for this reason the relative costs, as given later in this article, are based on the distribution of power to 60-inch projectors taking 200 amperes as their normal current. Search-lights in use are installed at widely separate points, stretching into a long line—



Connections of 48" 60" and 80" Electric Control Projectors

in one instance eleven miles. And these search-lights, as now installed, are in nearly every case remote from the generating station, making it necessary to furnish current to them through excessively long feeders, or to install a separate small generating plant for each light. The latter have generally been steam driven, and on account of concealment these small isolated plants have been located to the rear from 1,000 to 3,000 feet.

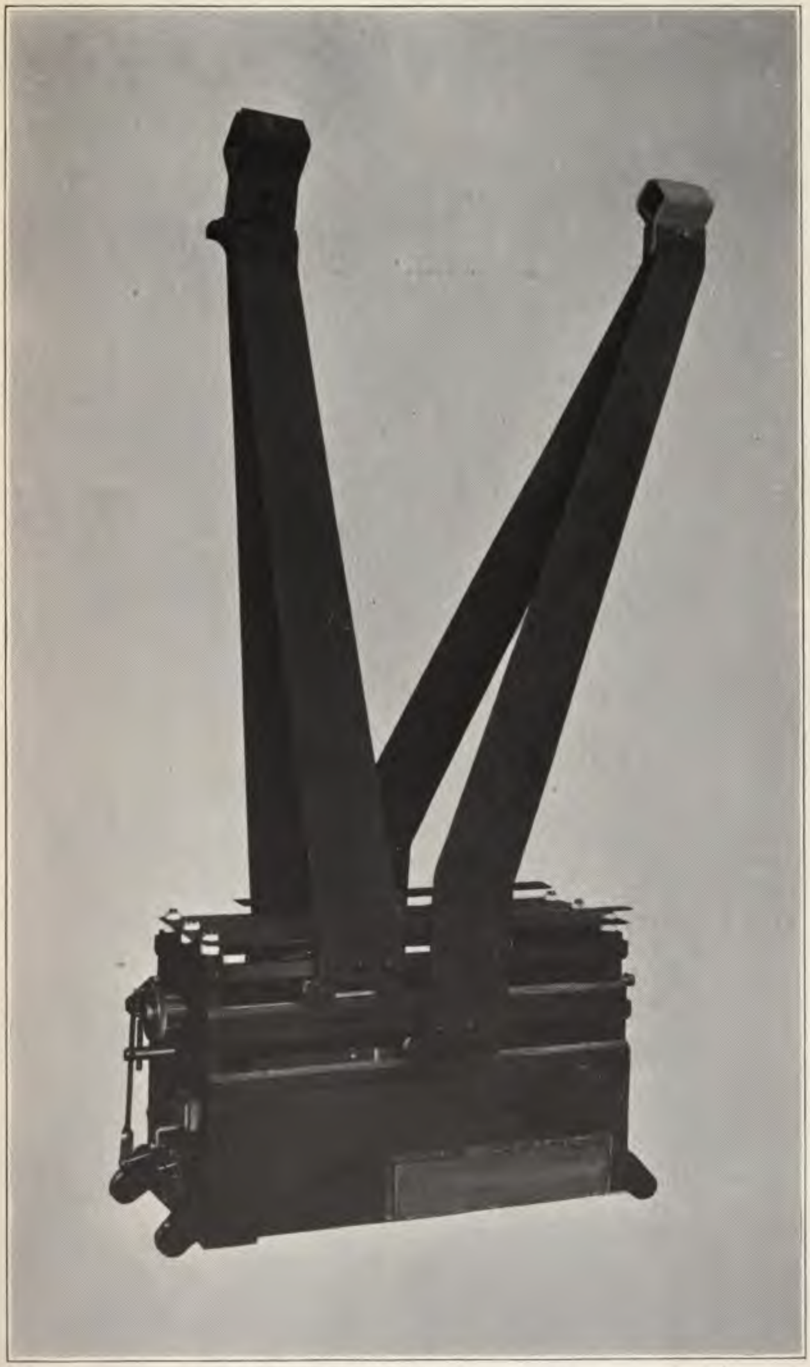
The search-lights require direct current for the arc, as alternating current is not as efficient or suitable; and while alternating current motors might be used for training, as the training motors require less than two per cent of the energy necessary for the arc, a direct current generator is used to supply the power for both the arc and the motors.

In order that the lamp mechanism may properly function, it is necessary to have a resistance in series with the arc; and it is recommended that the voltage of the generator be 110-125 volts, the arc requiring 65 volts and using 110-volt generator, these being 45 volts drop, with normal current, in the feeder cables and resistance of rheostat. It is advisable that the drop in the feeder cables be kept as small as possible, as the regulation at the terminals of the feeders or at the search-light depends largely on this. If no training motors were used it would be possible to dispense with the use of a rheostat, using a feeder cable that would give the necessary drop in voltage between the generator and the search-light. But in electrically controlled projectors, using motors for training the projector, it will not be possible to do this, for the reason that as the current varies in the arc, the terminal potential would also vary, and, with motors wound for 65 volts when the lamp was burning, would be subjected to a pressure of say 110 volts when the lamp was not burning, which is 70 per cent more than what they were designated for, and which, of course, would not be good treatment. With a generator of higher voltage the difference would be much greater. This would not only have an injurious effect upon the motors, but would influence their speed so that the speeds of training would vary between wide limits. It is, therefore, necessary to distribute energy to the projectors with the minimum drop in the feeder cables, reducing the voltage for the lamp by means of a rheostat, and maintaining the voltage at the training motors as nearly constant as possible. Again, on account of the distance of the point of control from the search-light, *i. e.*, length of controller cable, it is necessary to have the maximum generator voltage at the projector, in order that the resistance of the controller cable may not interfere with the proper working of the controlling system; otherwise the cross section of the conductors in the controller cable, and, therefore, the size of the cable, will have to be materially increased.

It is possible to distribute energy by either direct or alternating currents. By direct current, power may be distributed by several methods: by the two-wire low tension system; by the three-wire system and by by the use of 500 volts system with motor generating sets. The two-wire system is, at present, largely in use, yet it has but few advantages. On account of the long length of the feeder cable through which the current has to be transmitted, either an excessive amount of copper is necessitated or an extreme drop in the cable. The main advantage of this system is that it is more widely known, having been in use for some years, and enlisted men are more familiar with it than with any other. It is, however, no simpler than the other methods to be described later.

Where two search-lights are located sufficiently close together to enable one generating station to supply the power, these two projectors may be run on the three-wire system, using either two 110 or 125 volt generators in series, with a neutral brought back from the intermediate point, or a 220 or 250 volt generator with a derived neutral. This system will reduce the amount of copper that is usually necessary for two search-lights, as three wires may be used in place of four. All three cables should have the same cross section, for, in case only one light is running the neutral will have as much current to carry as any other wire, but when both are in operation, the neutral will carry only the balancing current. In practice, however, it is seldom that two projectors are located close enough to take advantage of this, and for this reason, in the comparison of costs, the system is not considered.

Relative to the 500 volt system, using motor generating sets, this has no advantage over the alternating current system, but on the contrary has not the flexibility, simplicity nor reliability of the alternating current system of distribution. A possible use of the 500-volt direct current system, where the radius of distribution is not too great, would be to equip cars, running on suitably located tracks, and self-propelled by motors, with a search-light and motor generating set for supplying proper voltage to the projector and controller, both the motor of the generating set and the self-propelling motor taking their power from the trolley. The advisability of having portable projectors, or of mounting them in permanent emplacements,



PROJECTOR LAMP AND MECHANISM.

is not discussed, other than to state that the latter method permits the use of a much more satisfactory and reliable system of power supply.

With the use of alternating current as a means of distributing energy, it is, of course, understood that some translating device must be provided at the terminals of the different feeders, in order that direct current may be supplied to the projectors, the alternating current being used only as a means of distributing the necessary energy. For this purpose alternating current is remarkably flexible and efficient. By reference to the curves of estimated costs it will be seen that, in spite of the fact that a motor generating set is necessary, the actual cost of installation is less than by any of the direct current systems of power distribution. Moreover, by this method, in nearly every case, one generating station can supply the power for all projectors in the district, rendering the use of small and inefficient isolated plants unnecessary, and doing away with the annoyance of distributing coal, oil, etc., to these troublesome steam plants. The efficiency of this method is much higher, as with all projectors run from a single station the generating units may be larger, the efficiency of generation much higher, and the cost of maintenance less. In such a station, it will be necessary to install alternating current generators with direct current exciters, and it is possible for one generator to supply energy to all the search-lights; but as a matter of precaution, it might be well to have a reserve set to throw in, in case of accident to the generator in operation. The alternating current will be generated at a potential of from 1,000 to 3,000 volts. Should it become necessary to transmit power to very remote points, the voltage may be stepped up by means of transformers for transmission over such lines at a higher voltage, reducing the copper cost and the line losses.

Although not recommended as standard design, in existing direct current stations a steam driven three-phase alternating current generator may be installed, or a motor generating set may be provided, taking direct current from the station bus bars, and driving a three-phase alternating current generator to supply power to the feeders. But it is a better plan to install a complete alternating current central station, of sufficient capacity to furnish all the power required within the radius of distribution; using alternating current motors wherever possible, and direct current only where it is absolutely necessary; such as for control of gun carriages and at the search-lights. At each search-light will be installed a three-phase alternating current motor-generating set, with the necessary transformer for stepping down the voltage. The efficiency of the motor generating set, including the transformers, will be approximately 75 per cent. If belted sets are used, the efficiency will be somewhat less; but the cost of the sets will also be less. The direct connected set, however, aside from its increased efficiency, is recommended on account of the smaller space occupied, and also for the reason that it is self-contained in every respect. The costs of distribution by alternating current system, as plotted in the curves, include not only the cost of the cable, but that of the motor generating set as well; in order to compare its cost with that of the cable alone as used with the low tension direct current system. The cost of the generator is not included, as some method, in either system, must be used to generate the necessary energy. It would be a very simple problem to supply power to a number of search-lights distributed along a line of defense as much as eleven or more miles long, by locating the power station sufficiently back to the rear for protection, and distributing power in both directions to the various projectors. And if necessary the voltage of the more distant lines may be stepped up by transformers thereby saving copper with the same per cent line loss as in the shorter lines.

This power station could supply the energy for all batteries, for the post lighting, and for the search-lights as well. Some might argue that it is dangerous to generate all the energy in one station: But if the station is properly located, the danger of its falling into the hands of the enemy, or of a projectile demolishing it, is extremely small. Should the reliability of this method be questioned, reference is made to the numerous commercial plants now in successful operation. The reason that commercial plants are successful is that competent men are in control; and this should be true of military plants as well. The central station and all electrical apparatus connected therewith should be in the hands of a commissioned officer, who should be held strictly responsible for the condition and efficient operation of the station, as well as for the pecuniary value of the property under his charge.

It should be noted that this alternating current apparatus, properly designed and installed, is remarkably simple in operation. The induction motor used in the motor generating sets for the projectors, is the simplest form of motor possible, having neither commutator nor brushes, and requiring the connection of only three wires to the starting device. This starting device is similar to starting rheostats of direct current motors, operating by reducing the starting voltage. For stepping up the voltage, and the reverse, the transformer is the simplest device possible,and operates at an extremely high efficiency. It consists of two coils on an iron core, with no moving parts whatever; it is difficult to see how such apparatus could get out of order with ordinary care.

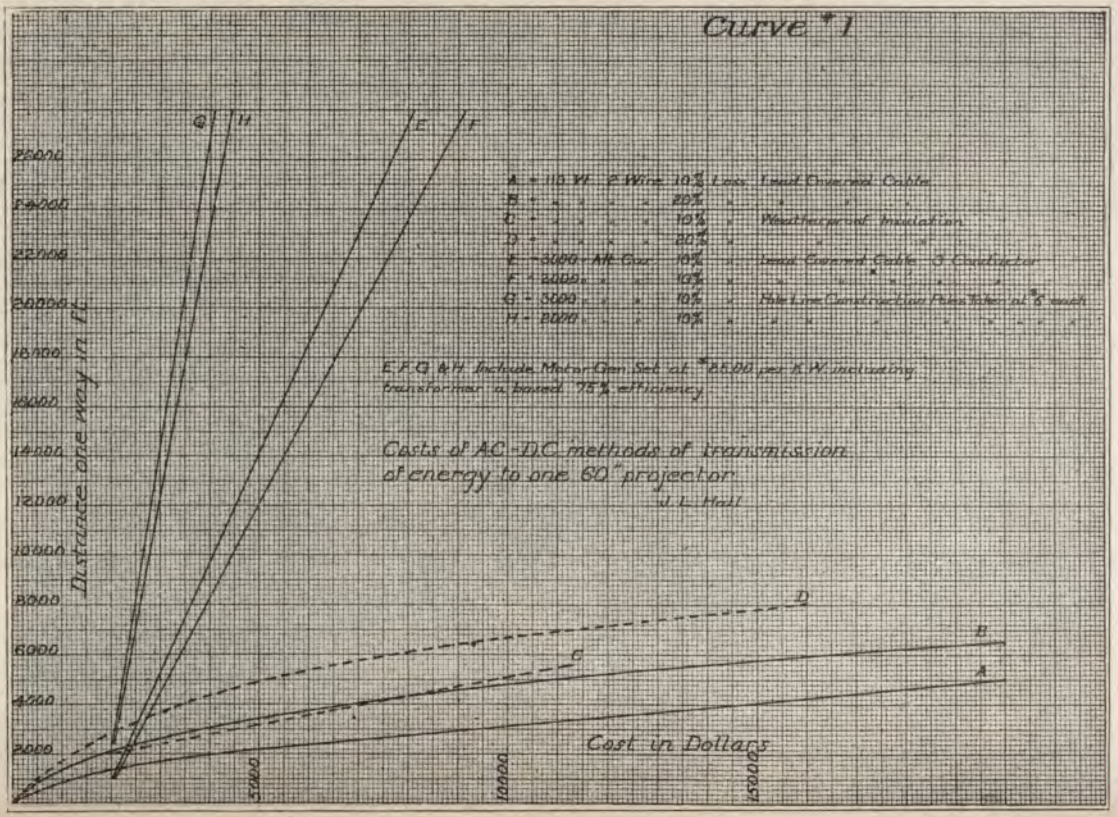
To explain the curves:

Curve No. 1 shows the relative cost of the different systems of transmitting energy from the generator to the projector.

Curve No. 2 shows the number of pounds of copper necessary for different distances of transmission, based on the 110-volt two-wire system with a loss of 10 per cent.

Curve No. 3 is the same as Curve No. 2, but based on 3,000-volt alternating current system, three phase, with 10 per cent loss.

In Curve No. 1: A is the cost of lead covered cable,110-volt two-wire system, 10 per cent loss; B is the same as A, only allowing for 20 per cent loss,C and D are the same as A and B,respectively,using wire with weather-proof insulation on a pole line construction. The cost of the poles, however, is not included. Also, in Curve No. 1 E and F are caste for alternating current of 2,000 and 3,000 volts respectively, with 10 per cent loss, using three-conductor lead covered cable. These curves also include the cost of a motor generating set necessary to change the alternating current into direct current at the projector. G and H, also in Curve No. 1, are the same as E and F respectively, but using wire with weather-proof insulation on a pole line construction, the price of the poles (six dollars a pole) included, and the poles spaced 100 feet apart. All line losses are in per cent of the delivered power, and alternating current lines have the wires separated eighteen inches, a frequency of 60 cycles, and 80 per cent power factor. With three conductor cables, the loss would be only that due to resistance.


Curve #1
A = 110 V. 2 Wire 10% Loss Lead Covered Cable
B " " " " 20% " " " "
C " " " " 10% " Weatherproof Insulation
D " " " " 20% " " "
E = 3000 Alt. Cur. 10% " Lead Covered Cable 3 Conductor
F = 2000 " " 10% " " " " "
G = 3000 " " 10% " Pole Line Construction Poles Taken at $5 each
H = 2000 " " 10% " " " " " " " "
E.F.G. & H. Include Motor-Gen. Set at $25.00 per K.W. including transformer & based 75% efficiency
Costs of A.C.-D.C. methods of transmission of energy to one 60" projector
J. L. Hall
Distance one way in Ft.
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
Cost in Dollars
5000
10000
15000
A
B
C
D
E
F
G
H